NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

FNMOC
MODEL VERIFICATION SYSTEM

by

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June 1998

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REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
June 1998

3. REPORT TYPE AND DATES COVERED
Master's Thesis

4. TITLE AND SUBTITLE
FNMOC MODEL VERIFICATION SYSTEM

5. FUNDING NUMBERS

6. AUTHOR(S) Kyongsuk P. Pace

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Postgraduate School
Monterey CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(maximum 200 words)*

Fleet Numerical Meteorology and Oceanography Center (FNMOC) forecasts the atmospheric environment and weather using several meteorological and oceanographic models. These models' forecasting abilities are verified by comparing the model forecast against the observational data and model's analysis. Currently, some models are verified by several inconsistent, maintenance-intense, non-standardized, and hard-to-use model verification systems designed for a particular model. Some models are not verified because there is no model verification system.

This thesis demonstrates the concept of a single model verification system for all FNMOC models to eliminate the inconsistencies and redundancies. The single model verification system standardizes the model verifications and provides the ability to verify those models which are currently unverified. The prototype used a GUI and web browsers to display the model verification statistics. The prototype demonstrates that convenient access to the model verification statistics could aid FNMOC users in evaluating the forecast models' performance.

This thesis identifies and documents the user specified verification requirements for several models and implements the most immediate requirements. A complete quantitative model verification system for all FNMOC models will be implemented incrementally, as all the requirements are identified.

14. SUBJECT TERMS
model verification, software engineering, prototype

15. NUMBER OF PAGES 206

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT
Unclassified

18. SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

19. SECURITY CLASSIFICATION OF ABSTRACT
Unclassified

20. LIMITATION OF ABSTRACT
UL

Approved for public release; distribution is unlimited.

FNMOC
MODEL VERIFICATION SYSTEM

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Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN COMPUTER SCIENCE

from the

NAVAL POSTGRADUATE SCHOOL
June 1998

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ACKNOWLEDGMENT

I want to thank FNMOC for allowing me the opportunity to pursue this degree. I want to thank all my friends at FNMOC who encouraged me when I was full of doubts and skepticism. I also want to thank Dr. Mike Zyda for making time in his busy schedule to provide me insightful and valuable advice. My thanks to Dr. Tim Shimeall and Dr. Mary Alice Rennick for their help and guidance on this thesis. Finally, my love and thanks to my husband Duane, my sons Robert, Steve, and Michael.

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I. INTRODUCTION

Fleet Numerical Meteorology and Oceanography Center (FNMOC) is a U.S. Navy organization responsible for preparing and disseminating a wide variety of weather and other environmental forecasts. These forecasts support a large and diverse group of civil and military users who are located throughout the world. These forecasts are generated by meteorological and oceanographic models maintained by FNMOC. The accuracy and timeliness of the model forecasts are critical because the model forecasts support operational missions. As part of the quality control process, the model forecasts are periodically verified. While the verification process and frequency vary by model, generally it is an ongoing process. The model verification process is currently accomplished by diverse processes. Generally, all verification systems calculate a variety of summary statistics. These summary statistics are then examined to identify strengths and weaknesses. The models are then modified to improve their forecast performance. These summary statistics are also included in the weekly, monthly, quarterly and annual model performance reports. These reports are read by many meteorological and oceanographic organizations.

This research attempts to provide an enhanced model verification system that streamlines and standardizes the model verification processes in FNMOC. An enhanced model verification system that can be used to verify all FNMOC models would streamline the model verification process. Additionally, a verification system which is easily modifiable to meet new requirements would provide enhanced capability. Furthermore, a system that is easily accessable to the model developers and managements would reduce difficulties in rapidly assessing verification data.

First, FNMOC needs a common verification system to verify all the model forecasts. Ideally this verification system should enable the users to make comparisons between several different combinations of verification parameters by controlling the independent variables. In other words, a verification system should provide the equivalent comparison statistics for the variable of interest. The comparison might be between models for the same geometry, between the atmospheric levels, between the forecasting period, etc. For example, if a user wants to compare one model's performance with another model's performance, the verification system should provide the equivalent comparison statistics for the different models in the same geometry, same atmospheric level, same forecast periods, etc., thus controlling these commonalities and providing only the true comparison statistics of the model performances.

Second, FNMOC needs a flexible verification system that can accommodate requirement changes. These changes could be an addition of a new model, change in the geometry where the models forecast, addition of new environmental parameters, etc. The requirement changes need to be incorporated immediately. Additionally, these changes should not require extensive modifications to the applications source code when each change is required.

Third, FNMOC needs an easy-to-use tool to access the verification statistics. It should be easy for the model developers and managers to use to generate the needed information in graphical format.

A. CURRENT MODEL VERIFICATION AT FNMOC

Currently, there is no single verification system for FNMOC model developers to use to access and easily analyze the models' performance. There are several model verification systems for different models developed by individual model developers and model verification personnel without adhering to any standards. For example, FNMOC's global meteorological model, Navy Operational Global Atmospheric Prediction System (NOGAPS), is verified by two verification systems, nogstat and verobs. Nogstat verifies NOGAPS forecast against its analysis and verobs verifies against the observational data. FNMOC's regional meteorological models, Navy Operational Regional Atmospheric Prediction System (NORAPS) and Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS), are verified against the observational data by verobs. Verobs compares NOGAPS and NORAPS in the NORAPS regions - Asia, Continental US (Conus), Europe and Indian Ocean. Verobs also provides NORAPS and COAMPS comparisons; however, their geometries do not match exactly. The different geometries add undesirable variability in the model comparison. Another example is FNMOC's global wave model, WAM_GLOBAL. It is verified by a verification scheme developed by the model developer. There is no known documentation and the developer is the only person who has any knowledge about the scheme. There are other systems that can only handle a single model or are very difficult to modify. Additionally, there are redundancies in the model verification efforts among many of the individual verification systems. Finally, some models do not have a verification system at all.

This lack of standardization also limits FNMOC's ability to rapidly respond to user's new requirements. As an operational center responding to a variety of operational users ranging from the Navy, Air Force and other civil and government organizations, FNMOC frequently receives requests to provide modifications to models. The ability to respond is limited by the fact that the data to compute the model verification statistics are in various formats at various locations. Some data are located in FNMOC's relational database, `Integrated Stored Information System (ISIS)` on the Cray and the Sun server. The model forecast data (grid data) and the model analysis are stored in the `ISIS` grid database. The observational data are stored in the `ISIS` latitude/longitude/time (LLT) database in a format different from the grid data. Some data are stored in a private directory as text files. All of these different data require different reading schemes. The model verification statistics are computed in many different ways since there is no single library to compute the statistics. The model statistics files are in different formats - some in text files, some in the Fortran formatted files, and in different locations - some on the Cray in the operational directory, some in private directories, some on a Sun system.

Finally, the accessibility to and the display of the data in the current systems do not provide the flexibility needed. Accessibility to the verification statistics is very limited in the current verification systems. Only users who have in-depth knowledge about the verification system can access the model verification data. The display of the model verification data is in numerous formats, styles and conventions. Notably, graphical displays with similar purpose are prepared using multiple graphical software packages. This results in a wide variety of styles and methods used to display similar model statistics. Clearly, there is a strong need for one universal model verification system to verify any FNMOC models and standardize the model verification process.

B. FNMOC MODEL VERIFICATION SYSTEM

The FNMOC Model Verification System is a single, easy-to-modify and easy-to-use model verification system for all FNMOC meteorological and oceanographic models. It was developed by modifying the current FNMOC operating verification systems `verobs` and `nogstat`. The new model verification system standardizes the model verification in FNMOC. It also makes the data and information widely available by leveraging web technology. It currently resides on FNMOC's intranet, but could be placed on FNMOC's internet server to meet the external user's requirements.

C. RESEARCH QUESTIONS

FNMOC model developers need a single, easily modified and easy-to-use model verification system that would standardize the model verification. This research attempted to address these needs through the following questions.

Is it feasible to develop a prototype system that demonstrates the concept of one universal model verification system to verify all FNMOC models? Will this system assist in eliminating redundancies and inconsistencies caused by the present system that uses multiple model verification methods? Is it feasible to implement a common system for those models that currently do not have a model verification system? Can this standardization of the model verification create a reusable statistics library and consolidate all model statistics in one database in a standardized data format? Can this model standardization be created using graphics with the same format, style and conventions?

Second, can a universal system provide the flexibility needed to rapidly and efficiently modify the model verification system for all FNMOC models? Will this flexibility meet requirements of FNMOC customers?

Third, can a web-based technology provide the access, and ease of use needed to meet the customer and FNMOC personnel needs?

D. THE OVERVIEW OF THESIS

Chapter I of this thesis provides an introduction and problem statement, Chapter II describes the Model Verification System including the background, Chapter III provides the user requirements, Chapter IV provides the design, Chapter V provides the evaluation and Chapter VI provides the recommendations for future research. Appendix A provides the values of the SMS environment variables and namelist values for each model using the system. Appendix B provides the source code. Appendix C provides the prototype testing data.

The figures in this thesis use Yourdon's [Ref. 1] graphical modeling notation. A process is represented by a rectangular box. A process that is further decomposed is represented by a shaded rectangular box. An input or output flow is represented by an arrow.

An external entity is represented by a box with a folded upper left hand corner. A decision point is represented by a diamond. A data store is represented by a drum. A library module is represented as a rectangular box with double side bars.

The `courier` font is used to indicate programs and systems external to the model verification system such as `ISIS` and `HTML`. The *italic* is used to indicate the parts of the model verification system such as the *graphics* component.

II. FNMOC MODEL VERIFICATION SYSTEM

The FNMOC Model Verification System is a single model verification system for all FNMOC meteorological and oceanographic models. It replaces the currently existing model verification systems that are redundant, hard to modify and maintenance intensive. It provides an easy-to-use model verification system for the models that do not currently have a verification system. It standardizes the model statistics computations by creating a reusable statistics library. It standardizes the format and storage of the model statistics by consolidating the model statistics in one location using one database management system. It also standardizes the display of the model statistics by using the graphics library routines created with FNMOC's graphics software. This system provides FNMOC model developers a easy-to-use tool to aid them in their analysis of model performance.

It uses web technology to enable the users to make their requests via web browsers and receive the resulting graphics as shown in Figure 1. Implementing the GUI via a web browser eliminates the requirement that the client system have all the necessary software locally, i.e., all the processing is done on the server.

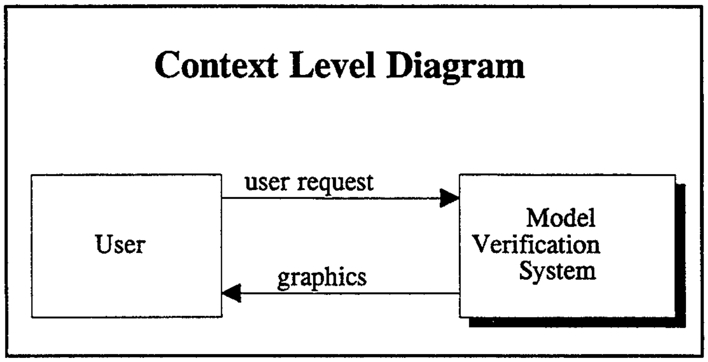


Figure 1. Context Level Diagram

The model verification system has several components. The *operational run (ops run)* component computes the model statistics twice a day after each model run is completed. The *statistics computation library (statistics library)* component is a reusable library that performs the statistics computation for this system as well as other systems (programs) at FNMOC. The *database for the model statistics (statistics database)* component is the single data storage for all the model statistics. The *graphics* component creates the graphs of the model statistics. The *user interface* component receives the user requests, processes them, then returns the resulting graphs back to the user via a web browser. The following sections describe these components in broad, general terms. More specific descriptions of these components are in Chapter IV.

A. OPERATIONAL RUN

FNMOC runs the prediction models twice a day. The model verification statistics are calculated after each operational run of the models. This component has four major parts. First, after the prediction model has successfully completed, the FNMOC operations staff uses the `Scheduler Monitor Supervisor (SMS)` system to invoke a `Korn` shell job script, *mverif.job*. This operational job script (*mverif.job*) is run on the same FNMOC Cray computer as the model forecasts, model analysis and the observational data. The *mverif.job* also executes the second and third parts of the operational run components, *verobs* and *veranal*. Additionally, it writes a set of text files that contain the calculated statistics to the appropriate directory and computer. Second, a group of Fortran programs, *verobs*, verifies the model forecasts against the observational data. Third, a group of Fortran programs, *veranal*, verifies the model forecasts against the model analysis. The model analysis is the initial conditions over a set of grid points covering the forecast region. Fourth, a Korn shell script, *statupd.ksh*, adds the computed model statistics to the model statistics database.

B. STATISTICS LIBRARY

The statistics library has a collection of reusable general purpose statistics programs. These programs are a group of Fortran programs that compute the required statistics for model verification. These include commonly used verification statistics such as mean error (bias), standard deviation of the error (stdev), and root mean squared error (rms). All the programs compute the statistics on the difference between the verifying and predicted sets of data. There is also a program to compute the map factors for different earth projections used by FNMOC.

The current FNMOC routines for computing statistics were modified and adapted in this component. The inventory of the existing statistics computation routines was obtained from the FNMOC Unix Utility Library and the applications under FNMOC configuration management (CM). Table 1 shows the existing Fortran subroutines and the statistics computed by each of them.

Table 1. Inventory of FNMOC statistics routines

Routine	Statistics computed
ancor.f	anomaly correlation (anc) for 10 NOGAPS areas
differp.f, differs.f*	mean bias, mean, sum, standard deviation (std), root mean square (rms)
htrms.f	mean bias, std, rms
nrancor.f	anc
nrhtrms.f	mean bias, std, rms
nrvelrms.f	mean wind u component, mean wind v component, mean wind speed, rms wind speed
stats.f	mean bias, rms, std, threat score, probability of detection (pd), false alarm, skill score
velrms.f	mean wind u component, mean wind v component, mean wind speed, rms wind speed for 10 NOGAPS areas

* The statistics computed do not take any projection into account. All the other subroutines compute the statistics for the spherical projection.

These routines are redundant, not in a particularly reusable form, and application specific rather than general purpose. For example, the routines `ancor.f`, `htrms.f` and `velrms.f` are specific to nogstat. The routines `nrancor.f`, `nrhtrms.f` and `nrvelrms.f` are specific to `norstat` (a no longer active modification of `nogstat`). The routine `stats.f` is specific to `verobs`. The routines `differs.f` and `differp.f` are part of yet another application `Ocean Model Support Program (OMSP)`. This component makes them more reusable and general purpose.

C. STATISTICS DATABASE

This component is the data storage for the model verification statistics. It uses

FNMOC's relational database system, Empress. There is a table for each model and a generic table structure used to create the table structures for each model's table. This database resides on the database workstation. This component allows easy data access and consolidates all the model statistics in a single location. It will have one year's data on line and archive the older data off line. This is to accommodate the model developers' requirements to frequently use the historical data for weekly, monthly, quarterly, seasonal and annual analyses and reports.

D. GRAPHICS

This component creates the graphs of the model statistics based upon the user's requests. The programs are written with one of FNMOC's graphics software packages, Interactive Data Language (IDL). These programs read the model statistics from a text file. The model statistics are retrieved from the database, formatted and written to a text file for IDL programs. The IDL program creates a GIF file to display in a Hyper Text Markup Language (HTML) page back to the user.

E. USER INTERFACE

This component is the gateway to the model verification system via a web browser. It gives the users the ability to compose their requests for the model verification statistics they want via HTML forms. When the users access the system they are presented with a variety of on-screen choices. These include a list of models, forecast periods (tau), atmospheric pressure levels, parameters (air temp, wind speed, etc.), statistics, and verification sources. Additionally, they can select the observation types and types of graphs and can also specify the time period they want graphically presented. After they make the various selections and request the information, their request is processed and the information is returned to their screen. Their request is processed dynamically, using a `perl` script. This is important since it eliminates the need to have any pre-created static `GIF` files. This is an important capability since static files are less flexible, use greater storage space, and require a great deal of maintenance to keep them current. The `perl` script parses the user requests, executes the script to query the statistics database and retrieve the data, executes the graphics programs and returns the graphs to the user via a web browser.

F. MEETING THE REQUIREMENTS

Each of the FNMOC Model Verification System components demonstrates the ability to eliminate shortfalls in the current system as well as providing additional enhancements. First, the operational run component computes the statistics twice daily for continuous accumulation of model statistics. It is designed for flexible modification whenever a requirement change occurs via `SMS` variables and the `namelist` functionality in Fortran 90. Additionally, the statistics database standardizes the data format, data storage, data access and data location by having all the model statistics in a single database. Also, the statistics library standardizes the statistics computation for all the map projections. The text file format for the intermediate files for the data insertion into the statistics database standardizes how the intermediate files need to be written. This is beneficial in the event these files need to be read directly or if the model statistics from some other systems need to be added into the statistics database. The *graphics* component creates the standardized graphs of the model statistics. The user interface component provides the users an easy-to-use model verification system for all FNMOC models. No special training is required to use the model verification system if users know how to use a web browser. It is a single point and common way to access the model statistics without any knowledge about the system. All these components help to standardize the various aspects of the model verification in FNMOC.

The FNMOC Model Verification System Prototype demonstrates the concept of a single, universal model verification system for all FNMOC models. It provides a vehicle for a better understanding of the environment and requirements problem being addressed. It demonstrates what is actually feasible with the existing technology, and where the technical weak spots still exist at FNMOC. Additionally, it is an effective way to ensure the requirements accurately reflect the user's real needs. The prototype demonstrates to the users what is functionally feasible and provides an analysis test bed and vehicle to validate and evolve the system requirements. [Ref. 17]

III. REQUIREMENTS

A. GENERAL REQUIREMENTS

Generally, the model forecasts are verified against the observed meteorological values or the initial conditions over a set of grid points covering the forecast region called the model's analysis. "V. Bjerknes in 1904 recognized that forecasting is fundamentally an initial-value problem in mathematical physics and, moreover, that the basic system of equations to be solved was already known, at least in general form." [Ref. 10] This research addresses a part of the general requirements, verification against the observational values, but future efforts could expand to address the entire general requirements in the future.

B. FNMOC USER REQUIREMENTS

FNMOC user requirements were obtained through a user survey, review of the current model performance summary reports [Ref. 13], and a meeting with the model team leaders and model verification personnel. The initial user requirements indicated that the models need to be verified against the model's analysis and/or observational data which matches with the general requirements. The verification against the observational data appears to be more widely and frequently used at FNMOC. Therefore, this research concentrated on the verification against observational data initially and will add the verification against the model's analysis in the future. Table 2 below shows the results of the user requirements analysis for each model. The requirements analysis also showed that bias, standard deviation (stdev) and root mean square (rms) are used more frequently than any other statistical measures. Users indicated that the various model statistics should be stored on-line and immediately accessible for up to one year and off-line for longer period. The users indicated the most widely used graphics to display these statistics are scatter plots, time-series plots and height-series plots.

Table 2. List of user requirements for each models

model	geometry	parameter	levels	taus	stats	verif_source
NOGAPS	global_360x181	air_temp, geop_ht, pres, wnd_spd	sfc, 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100	0-144 at 12 hour increment	bias, rms, std	obs
NOGAPS	global_360x181	air_temp, geop_ht, pres, wnd_spd	sfc, 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100	0-144 at 12 hour increment	anc	anal
NOGAPS	asia_nest1_appl, conus_nest1_appl, europe_nest1_appl, ind_ocn_nest1_appl	air_temp, geop_ht, pres, wnd_spd	sfc, 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100	0-48 at 12 hour increment	bias, rms, std	obs
NOGAPS	europe_nest2_appl2	air_temp, geop_ht, pres, wnd_spd	sfc, 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100	0-48 at 12 hour increment	bias, rms, std	obs
NOGAPS	europe_nest3_appl2	air_temp, pres, wnd_spd	sfc	0-24 at 6 hour increment	bias, rms, std	obs
NORAPS_ASIA	asia_nest1_appl	air_temp, geop_ht, pres, wnd_spd	sfc, 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100	0-48 at 12 hour increment	bias, rms, std	obs
NORAPS_CONUS	conus_nest1_appl	air_temp, geop_ht, pres, wnd_spd	sfc, 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100	0-48 at 12 hour increment	bias, rms, std	obs
NORAPS_EUROPE	europe_nest1_appl	air_temp, geop_ht, pres, wnd_spd	sfc, 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100	0-48 at 12 hour increment	bias, rms, std	obs

model	geometry	parameter	levels	taus	stats	verif_source
NORAPS_IND_OCN	nd_ocn_nest1_appl	air_temp, geop_ht, pres, wnd_spd	sfc, 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100	0-48 at 12 hour increment	bias, rms, std	obs
COAMPS_EUROPE	europe_nest2_appl2	air_temp, geop_ht, pres, wnd_spd	sfc, 1000, 925, 850, 700, 500, 400, 300, 250, 200, 150, 100	0-48 at 12 hour increment	bias, rms, std	obs
WAM_GLOBAL	global_360x181	sig_wav_ht, peak_wav_per	sfc	24-120 at 12 hour increment for obs, -24 to -120 by 12 hour increment for anal	bias, rms, std	obs, anal
PIPS_N_HEM	n_hem_280x360	ice_cvrg, sea_temp	sfc	24, 48, 72, 120 for obs 1,2,3,5-day old for anal (persistence)	bias, rms, std	obs, anal
OTIS_GLOBAL	global_360x181	sea_temp	dpth_sfc, **	0 for obs 1,2,3-day old for anal (persistence)	bias, rms, std	obs, anal
OTIS_W_ATL	w_atl_211x186	sea_temp	dpth_sfc, **	0 for obs 1,2,3-day old for anal (persistence)	bias, rms, std	obs, anal
OTIS_W_PAC	w_pac_201x201	sea_temp	dpth_sfc, **	0 for obs 1,2,3-day old for anal (persistence)	bias, rms, std	obs, anal
TOPS_GLOBAL	global_360x181	sea_temp	dpth_sfc, ***	24, 48, 72	bias, rms, std	obs

model	geometry	parameter	levels	taus	stats	verif_source
TOPS_W_ATL	w_atl_211x186	sea_temp	dpth_sfc, ***	24, 48	bias, rms, std	obs
TOPS_W_PAC	w_pac_201x201	sea_temp	dpth_sfc, ***	24, 48	bias, rms, std	obs
MISC_GRIDS	n_hem_900x136	ice_cvrg	dpth_sfc	0	bias, rms, std	obs
SSM/I OI	s_hem_900x91	ice_cvrg	dpth_sfc	0	bias, rms, std	obs

** 0, 2.5, 7.5, 12.5, 17.5, 25, 32.5, 40, 50, 62.5, 75, 100, 125, 150, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1750, 2000, 2500, 3000, 4000, 5000 meters

*** 0, 2.5, 7.5, 12.5, 17.5, 25, 32.5, 40, 50, 62.5, 75, 100, 125, 150, 200, 300, 400 meters

C. ASSUMPTIONS

Several assumptions were made during this research to focus on meeting the most urgent requirements. First, this research concentrates only on verifying the model forecast against the observational data since more users indicated they would like to verify against the actual data. The assumption here is that the results and methodology can be generalized to the verification versus the model analysis as well. Second, the system is purposely designed to be as independent from FNMOC's relational database management system (RDBMS) `Empress` as possible by using the text files between the DBMS and the system in the event the DBMS is changed to some other RDBMS. The assumptions is that these text files can be interfaced with any RDBMS. Third, `WAM_GLOBAL` is used as the representative ocean model in the initial system rather than all the ocean models. Other ocean models as well as the meteorological models will be added later. This assumes that the results and methodology can be generalized to other models as well. Fourth, the system only calculates the bias, stdev and rms initially and will add the other statistics later. The asumption is that other statisics can be added.

The system will evolve and mature as the users' inputs from the user prototype evaluations are evaluated. More general verifications will be implemented as the full system is implemented to meet all the requirements identified during the requirements analysis, namely, the verification against the model analysis, the addition of other oceanographic and meteorological models, the addition of statistics (anomaly correlation, probability of detection, threat scores, etc.), consideration of the map factors in the verification against the model analysis and addition of other graphics for different combinations.

D. LIMITATIONS OF RESEARCH

This research demonstrates the concept of a universal model verification system for all FNMOC models by use of a prototype system. This prototype is implemented to meet the minimum requirements, but provides the capability to expand to meet the additional requirements as well as future requirements. The limitations in the system are listed in the following paragraphs.

The model statistics is computed for different observation types separately rather than combined. The map factors are not considered in the verification against the observations. In other words, when the model forecasts are verified with respect to the observational data, all the latitude/longitude points are considered equally weighted. This system creates only the time-series plots to narrow the scope of the graphics component. Other types of graphics can be added in the future.

The prototype is bound to the current FNMOC operating systems and software since it should use the FNMOC environment. Therefore, this system may not be as portable as it could be when there is a significant change within the FNMOC environment, such as a different operating system, new DBMS, new graphics software, new standard shell, etc. Some of the lower level modules that interface to the ISIS latitude/longitude/time (LLT) data have unavoidable coupling to ISIS due to the different observational data type structures.

IV. DESIGN

The initial prototype system design has narrow scope to concentrate on meeting the immediate and minimum requirements. Additional requirements will be added in future versions to test the system's flexibility. The immediate requirements are verification of the NOGAPS, NORAPS, COAMPS and WAM_GLOBAL models after the model runs for daily, weekly, monthly and quarterly reports. The prototype will present bias, stdev and rms on a few specified parameters (e.g., air temp and wave height). The WAM_GLOBAL model is used as a representative ocean model in the prototype.

The prototype of the initial system addresses these requirements to prove the design and implementation concept. Additionally, this will demonstrate the feasibility of using a single universal model verification system for FNMOC. "The system need not have a finely tuned prototype before it is implemented. In fact, one merely asks of the prototype that it contains a flexible set of hardware and software tools for continuous redesign, and have access to real-time data (with standardized formats)." [Ref. 15] The prototype has a GUI to allow the users to view the model statistics in graphical form on a web browser.

The prototype is developed and implemented in FNMOC's operational environment to ensure that it is useful in that environment. "The important thing is that the development takes place primarily in the operational office, with the direct involvement of the people who are going to use it." [Ref. 15]

A. OVERALL STRUCTURAL DESIGN

Figure 2 shows the overall structural design of the FNMOC model verification system. It shows the five main components described in Chapter II and their relationships.

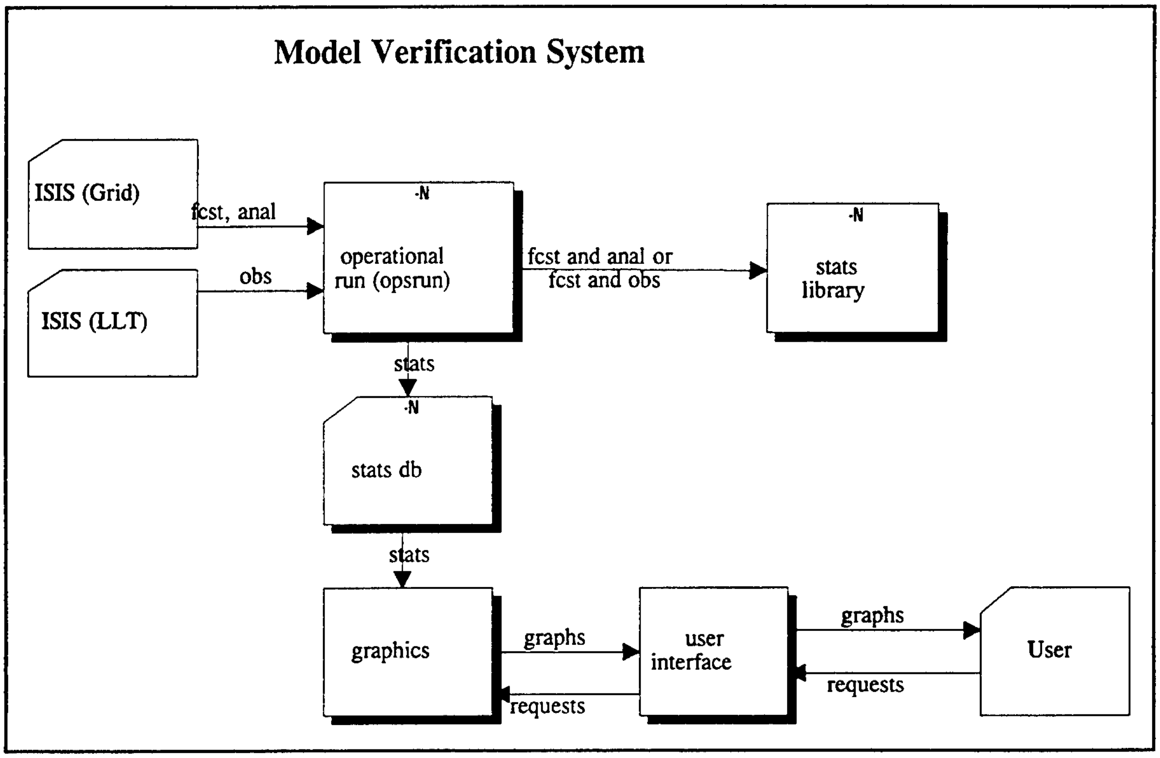


Figure 2. Level 1 Diagram

The *operational run* component computes the model verification statistics twice a day by executing either *verobs* or *veranal*. *Verobs* reads the model forecasts and analysis from the ISIS grid database and observational data from the ISIS LLT database. *Verobs* and *veranal* use the statistics computation routines in the reusable *statistics library* component to perform the computation. They write the statistics in the text files in the standardized format (one for each model) for transfer to the FNMOC database development workstation where the *statistics database* component resides. The *operational run* component then inserts the model statistics into the database. The transfer and the database population is not done twice a day by FNMOC operations currently as part of the ops run because operations is not one of the owners of the *statistics database* component. Currently, the transfer and database populations are done by FNMOC staff about once a day during the week days. This is because the *statistics database* is not part of ISIS currently, and the FNMOC ops run does not write to any non-ISIS databases. The *statistics database* should become a part of ISIS after the prototype evaluation. The *user interface* component presents HTML forms to users which they use to make their requests. This component processes the user requests by retrieving the model statistics from the *statistics database* and formats the data for the *graphics* component. The *graphics* component then creates the graphics to send to the users. The following sections describe the detailed design for each module in each of the five components. The source code for all the modules is in the Appendix B.

B. DESIGN OF OPERATIONAL RUN (OPS RUN)

The ops run has two korn shell scripts, *mverif.job* and *statupd.ksh*. It also has Fortran programs *verobs.f90* and *veranal.f90* (in the future) along with a Fortran header file *v_data.h*. *mverif.job* reads the SMS variables and executes the appropriate program based on the SMS variable VERIF_SOURCE value. FNMOC operations executes this job script to compute the model verification statistics twice a day after each model run is completed. The model statistics are written to a text file for each model, geometry and date-time-group (dtg). *Statupd.ksh* transfers the model statistics text files from one computer to another workstation, formats the text file and populates the statistics database using Empress Standard Query Language (SQL). Figure 3 shows the design of ops run graphically.

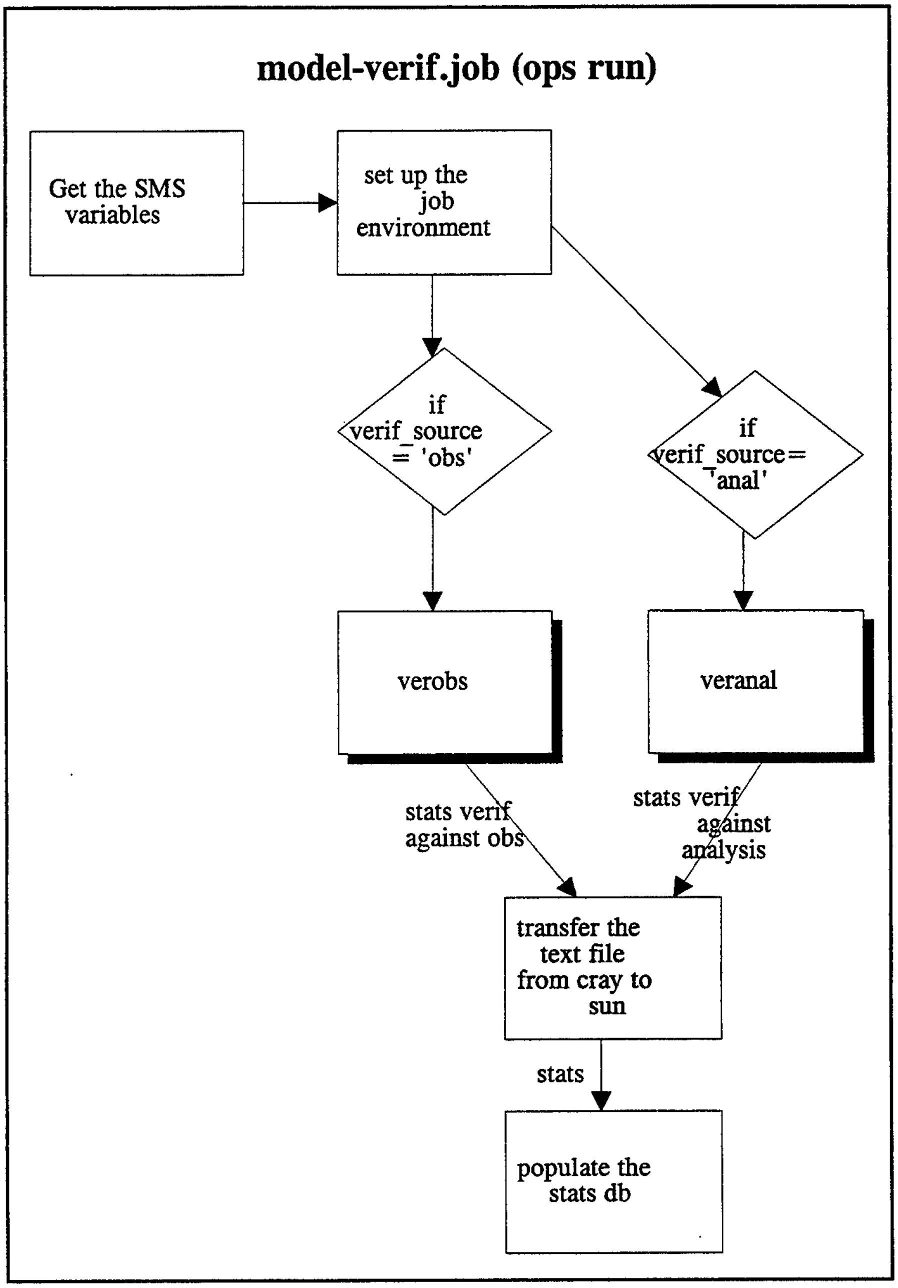


Figure 3. Ops Run Diagram

1. Design of mverif.job (Cray)

This system needs to be flexible to incorporate new requirements and changes to the existing requirements. The use of SMS environment variables in *mverif.job* is one of the methods this system uses to assure this flexibility. FNMOC uses SMS to run the operational runs (ops runs) and uses the SMS environment variables extensively to control the ops runs. The SMS variables are set before the *mverif.job* is executed and passed into the job. Figure 4 shows the list of the SMS variables and their description. By changing the value of these SMS variables, *mverif.job* is executed to verify all the FNMOC models without changing the job itself. The values for these SMS variables were set based on the user requirements analysis shown in Table 1. The complete SMS value list for each model is included in the Appendix A.

CRDATE - watch date-time-group (e.g., 1998013112)
ISIS_TABLE - ISIS table name, coincides with the model name (e.g., NOGAPS, WAM_GLOBAL)
GEOMNM1 - geometry name defined in ISIS (e.g., global_360x181)
GEOMNM2 - second geometry name
TAUI - beginning forecast time
TAUE - ending forecast time
TAUINC - increment of forecast time
VERIF_SOURCE - either 'obs' or 'anal'
OPSBIN - directory in which the binaries for the operational runs reside
ISIS_INIT - ISIS initialization script name
PROGBIN - directory in which the binary for this system resides, may be same as OPSBIN

Figure 4. SMS Variables and Description

mverif.job is a korn shell script that FNMOC operations execute to compute the model verification statistics twice a day. This job performs various operational job required tasks such as setting up the operational job environment and executing the correct ISIS initialization script. It reads the required SMS variables and exports them to the subsequent shells. It creates the appropriate sub-directory with the month (mmm, e.g., mar) and year (yyyy, e.g., 1998) from CRDATE to write the model verification statistics. There are separate sub-directories for each month and year. It copies the model's namelist files to the $TMP directory and executes the appropriate executable file based on the variable VERIF_SOURCE's value as shown in Figure 3. If the value of VERIF_SOURCE is 'obs,' *verobs* is executed and if the value is 'anal,' *veranal* is executed. It then writes the resulting model statistics into the standardized text file in the appropriate data directory (/a/ops/etc/dynamic/app/mverif/mmmyyyy). It finishes the process by completing the job accounting information and writing the joblog file to the operational joblog output directory (/a/ops/job/out).

2. Design of statupd.ksh (Sun)

This is a korn shell script that inserts the model statistics into the appropriate data table in the statistics database, *stat_db*. It is executed after mverif.job is finished. It formats the transferred text file using the awk. *Statupd.ksh* determines if new statistics files exist in the data directory. It also determines the database table to populate based on the model name in the statistics files. It then inserts the statistics into the appropriate data table in *stat_db*.

3. Design of Fortran Include File, V_DATA.H

All data definitions and constants used throughout the Fortran 90 programs (*verobs, veranal*) and their subroutines are in the Fortran include file called *V_DATA.H*. This provides for easier maintenance since the modification is isolated in one location rather than in multiple locations when changes in a variable occur.

4. Design of VEROBS.F90, The Main Verification Against Obs Program

This is the top level Fortran program that verifies the model forecasts with respect to the observational data for various models. *Verobs.f90* uses the namelist functionality. This helps to achieve flexibility in addition to the usage of the SMS variables. Like the SMS variables, namelist values are set external to the program. Each model can have a namelist file for the surface level and a namelist file for the upper levels. The namelist files are explained in more detail in subsection ***a*** below. Figure 5 shows the structural design of verobs module.

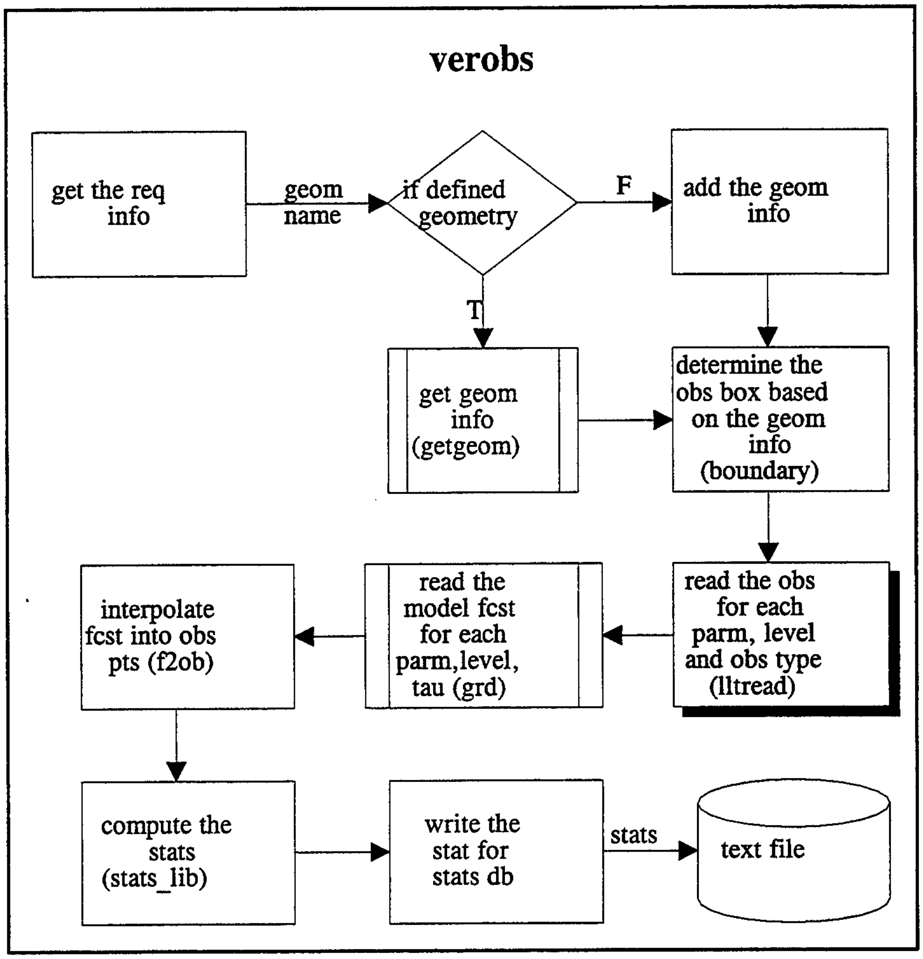

verobs
get the req info
geom name
if defined geometry
F
add the geom info
T
get geom info (getgeom)
determine the obs box based on the geom info (boundary)
read the obs for each parm, level and obs type (lltread)
read the model fcst for each parm,level, tau (grd)
interpolate fcst into obs pts (f2ob)
compute the stats (stats_lib)
write the stat for stats db
stats
text file

Figure 5. Verobs Design

Verobs.f90 reads the SMS environment variables described in the *ops run*. It determines if the geometry in GEOMNM1 is defined in the ISIS. If it is not defined, the geometry information is added. Once the geometry is defined, it determines the earth area to read the observations for the model verification. It then reads the model forecast from the ISIS grid database and observations from the ISIS LLT database. It interpolates the model forecast to the observational data points to compute the bias, stdev and rms using the *statistics library* component. It writes the statistics to a text file. The text filename is determined by the SMS variable values for ISIS_TABLE, GEOMNM2 and CRDATE. The modules (Fortran subroutines) called by *verobs* are described in the following sections starting in section ***b***.

a. Namelist file format for each model

Each model can have two namelist files, one for the upper environmental levels and one for the surface level. The second namelist file is needed because the surface level is different for different parameters and level types while the upper levels are common levels for all the parameters. For example, the surface level for air temperature is 2.0 meters, while the surface level for wind speed is 19.5 meters. Figure 6 shows the list of the namelist items and their descriptions. The complete namelist files for each model are included in Appendix A along with Table 3. Table 3 shows the namelist items specified by the users for each model.

parm - the list of model parameters to verify
dsetname - the data set name for the model forecast parameter in ISIS grid data
obs_parm - the corresponding parameter in the observational data in ISIS LLT data
odsetname - the data set name for the observational parameter in the LLT data
units - unit of the given parm
lvltype - level type of the given parm
obstype - the observational type to read from LLT data
level - vertical level to read
stat - type of statistic to compute (bias, std, rms)
tval - threshold value for the threat score, probability of detection, false alarm, and skill score; it will be an optional item since it is not always be used.

Figure 6. Namelist Variables and Description

For each value of parm, there must be a corresponding value for dsetname, obs_parm, odsetname, units, lvltype and obstype. For example, if the parm value is 'air_temp,' there must be values for the dsetname which can be 'fcst_ops,' the obs_parm which should be 'air_temp,' the odsetname which can be 'fnmoc,' the units which should be 'deg_K,' the lvltype which can be 'isbr_lvl' and the obstype which can be 'raob_qc.'

b. boundary

This Fortran subroutine determines the geographical area from which to extract observations to use in the verification. It computes the minimum and maximum latitude and longitude for a given geometry's area box. These minimum and maximum latitude and longitude are required for reading the observational data from `ISIS` llt database. It fills the single dimension arrays, x and y, with the values representing the left, right, bottom and top boundaries. It converts x/y values to latitude/longitude values by calling FNMOC utility, `vxyll`. It then finds the minimum and maximum latitude and longitude.

c. *f2ob*

This Fortran subroutine interpolates the model forecast fields to the observation locations. It obtains the number of rows and columns for the geometry defined by GEOMNM2 by the ISIS utility getgeom and finds the maximum array dimensions for x and y arrays. It converts observations latitude/longitude points to x/y values by calling FNMOC utility, vllxy. It then interpolates the model forecast to the observation points by calling FNMOC utility, fintrp.

d. *intgeom*

This Fortran subroutine interpolates one geometry to another geometry. This interpolation is necessary when a model needs to be verified in the geometry other than the geometry in which it is stored. For example, the global models such as NOGAPS are compared to the regional models such as NORAPS_ASIA in the same Asia region. It gets the information on the two geometries defined by GEOMNM1 and GEOMNM2 by calling the ISIS utilities ggrd and getgeom. It then interpolates the first geometry to the second geometry points by calling the FNMOC utility chgeom.

e. *lltread*

This Fortran subroutine calls the appropriate LLT read subroutine based upon the observation type. This subroutine acts as the middle man between the main program *verobs* and the llt read subroutines for each observation type. There are separate LLT read modules for each observation types because the include files and the data structures in ISIS are different for different observation type. For example, the observation type 'raob_qc' is read by the *raob_qc_read* subroutine. The subroutine *raob_qc_read* uses two ISIS includes files, `common.inc` and `RAOB_QC.H`. It has to use the data structure TYPE (raob_qc_int) and TYPE (raob_qc), and use the 'raob_qc' sequence type in the call to the `ISIS` LLT read utility `lrd`. Currently, *verobs* reads only the observation types, raob_qc, sfc_lnd, sfc_ship, sfc_ship_met_qc and alty using *raob_qc_read, sfc_lnd_read, sfc_ship_read, sfc_ship_met_qc_read* and *alty_read*, respectively. Other observation types will be added as more models and parameters are added to the model verification system.

C. DESIGN OF STAT LIB

The requirements analysis indicated the following statistics should be included in the initial prototype: Mean error (bias), standard deviations (stdev), root mean square (rms), anomaly correlation (anc) for most of the model parameters and threat score, probability of detection, false alarm, and skill score for selected model parameters. This research focusd on just the first three statistics since they are most often used. The other statistics will be added in future versions. Some of the existing routines will be modified to make them more general purpose and added as part of the statistics library. The design of each statistics module is described in the following sections.

1. Map Factors

The basic formula for the statistics are the same, but the statistics routines need to take the map projections into account to compensate for differences in earth area at different latitudes on the earth. This is achieved by applying a map correction factor at each grid point. Then the routines calculate the area using the new x- and y- coordinates. The general mathematical formula for the statistics is

$$\int_{\text{surface}} s(\lambda,\varphi)\delta a \,/\, \text{surface area} = (\sum s_n\ W_n) \,/\, \sum W_n$$

where s=value at a given i/j grid point, λ=longitude, φ=latitude, W_n are weighting factors.

There are two distinct cases to consider in the weighting factors or map factors. First, the observations are all independent. Therefore, each observation has equal weight, and the statistics formula becomes a simple average formula. Second, the grid points in which they lie must be weighted according to the relative size of the physical area related to the map factors for the relevant projection. In general,

$$W_n = (\Delta x_{ij}\ \Delta y_{ij})_n$$

where $\Delta x_{ij} = h_x \Delta\lambda_{ij}$, $\Delta y_{ij} = h_y\ \Delta\varphi_{ij}$, h_x and h_y depend on the map projection and $\Delta\lambda$ is the difference between two longitude, and $\Delta\varphi$ is the difference between two latitude of the box the s value lies.

According to FNMOC's model meta data database table, `ops_meta_grid_db.grid_reg_geom`, FNMOC's models use polar stereo, spherical, lambert, and mercator projections. FNMOC verifies `NOGAPS` in spherical projection against its analysis with the map correction factor currently. Some models are verified without the map projection consideration against the observational data with the assumption that each observation has the equal weighting factor of 1. The map factors for each map projection used at FNMOC are as follows: [Ref. 10, Ref. 12]

Spherical:
$h_x = \cos\varphi_{ij}$
$h_y = 1$

Polar Stereo:
$h_x = h_y = (½)(1+\sin\varphi_{ij})$

Mercator:
$h_x = h_y = \cos\varphi_{ij} / \cos\varphi_0$
where φ_0 is the latitude at which the projection is "true" and can be obtained from FNMOC database attribute geom_parm_1 in degrees.

Lambert:
$h_x = h_y = (\cos\varphi_{ij}/\cos\varphi_1)^{1-K} [(1+\sin\varphi_1) / (1+\sin\varphi_{ij})]^K$
where $K = \ln(\cos\varphi_1/\cos\varphi_2) \div \ln[\tan(\pi/4 - \varphi_1/2) / \tan(\pi/4 - \varphi_2/2)]$
φ_1, φ_2 are standard latitudes of the projection; their values can be obtained from FNMOC database attributes geom_parm_1 and geom_parm_2 in degrees.

2. Bias (Mean Error)

"Error is the simple difference of forecast minus verifying analysis or observation. The difference (error) field provides a quick look at a model's forecast performance or bias. Bias or tendency describes whether a synoptic field or feature is under or over-forecast." [Ref. 13] The advantage of the simple difference fields is that they are easy to compute and understand. They provide a quick look at the model forecast performance. [Ref. 13] The formula used for bias is

$\Sigma(F_n - O_n) W_n / \Sigma W_n$ where F is forecast, O is the observation.

3. Standard Deviations (stdev)

"Standard Deviation (stdev) is a measure of the scatter or variability about the mean in a series of observations. Standard Deviation is the positive square root of the variance." [Ref. 13] The formula used for stdev is

$$\text{sqrt } [(\Sigma((F_n - O_n)^2)W_n) / \Sigma W_n) - (\Sigma((F_n - O_n)W_n) / \Sigma W_n)^2].$$

4. Root Mean Square (rms or rmse)

"Root Mean Square Error (RMSE) is defined as the positive square root of the mean square error (MSE). MSE is the mean square of any residual. RMSE is the also called the standard error of estimate." [Ref. 13] "The RMSE is a quadratic score that gives the average magnitude of the errors. This statistics gives more weight to large errors than to small errors in the average, and is useful when large errors are undesirable." [Ref. 16] The formula used for rms is

$$\mathrm{sqrt}\ ((\Sigma(F_n - O_n)^2\ W_n) / \Sigma W_n)\ .$$

D. DESIGN OF STATISTICS DATABASE

The *statistics database* component uses FNMOC's RDBMS, `Empress`, to consolidate all the model statistics in one location. The database has a table for each model. The data in the tables are based upon the model developers' recommendations. A consolidated database will speed up the data retrieval and insertion. It will also accommodate modifications if the table structure needs to be modified for a particular model in the future. Figure 7 shows the `SQL` command used to create the generic table *model_stats*.

```
CREATE TABLE MODEL_STATS
   (verif_date        character(10,1)       not null,
    sample_size       integer               not null,
    parm_name         character(32,1)       not null,
    unit_name         character(32,1)       not null,
    geom_name         character(32,1)       not null,
    lvl_type          character(24,1)       not null,
    level_1           float(2)              not null,
    tau               integer               not null,
    stat_type         character(16,1)       not null,
    stat_value        float(2)              not null,
    verif_source      character(8,1)        not null,
    obs_type          character(24,1)       not null)

Indices: NORMAL (2, 15) parm_id ON (parm_name)
         NORMAL (2, 15) geom_id ON (geom_name)
         NORMAL (2, 15) level_1_id ON (level_1)
         NORMAL (2, 15) tau_id ON (tau)
         NORMAL (2, 15) stat_type_id ON (stat_type)
         NORMAL (2, 15) obs_type_id ON (obs_type)
```

Figure 7. SQL used to create the generic table

The basic table attributes are shown in Figure 8. This structure was saved in a file *stattbl* by the Empress command *'display model_stats all dump into stattbl;.'* The tables for other models were created using the structure stored in the file *stattbl* by the Empress command *'create nogaps from stattbl;'*.

The use of the indices improved the retrieval performance from greater than 3 minutes to less than 5 seconds. However, the insertion performance was degraded especially as the number of records increased. The tradeoff between these two scenarios favored the increase in the retrieval performance. The compromise may be to drop the indices, perform the insertion, then rebuild the indices every time data are updated according to a local database expert, but this compromise has not been tried for this research.

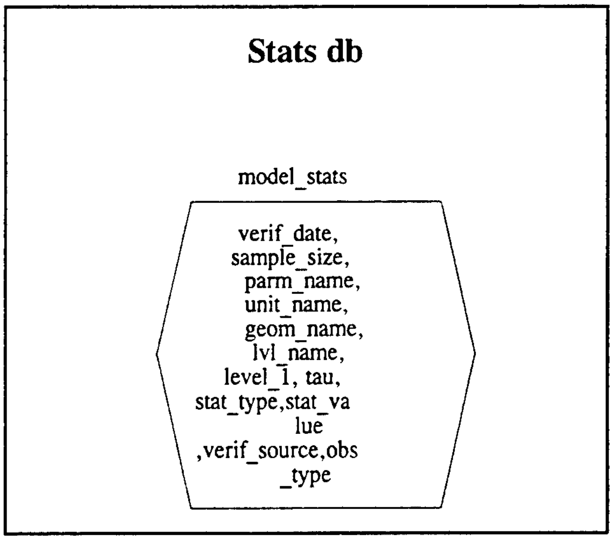


Figure 8. Statistics Table Attributes

E. DESIGN OF GRAPHICS

The *graphics component* consists of one `IDL` program currently in the prototype. This `IDL` program plots the bias, stdev and rms for a single model, single geometry, single parameter, single forecast period, single atmospheric pressure level and single observation type on one graph. More `IDL` programs will be added in future enhancements to create the graphs for other combinations. The `IDL` program creates a `GIF` file for display in web browsers. Figure 9 shows the structural design of the *graphics component*.

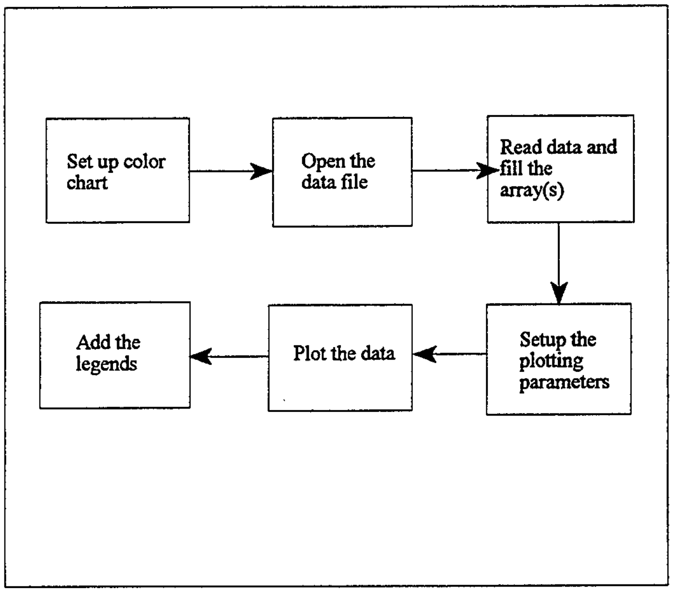


Figure 9. Graphics Design

The IDL program reads the data from a text file into the IDL array. It reads various environment variables to use within the program. It builds sub-arrays based upon the statistics type, e.g., bias, stdev and rms. Future IDL programs will build different sub-arrays based on the models, geometries, forecast periods, atmospheric pressure levels, or observation types. It formats FNMOC's 10-digit date-time group (1998032000) into a more meaningful date-time format (00Z 20Mar 98) to use on the x-axis label. It plots the bias and rms with different symbols and colors, and stdev as the shaded areas above and below the bias as requested by the users. Future IDL programs will create the scatter plots and other plots as the requirements change. An example of the current graphs is shown in Figure 13 in the next section.

F. DESIGN OF USER INTERFACE

Figure 10 shows the structural design of the *user interface* component. This component ties together the *statistics database* and *graphics* components. It has a GUI and `Common Gateway Interface (CGI)` to give the users access to the model statistics.

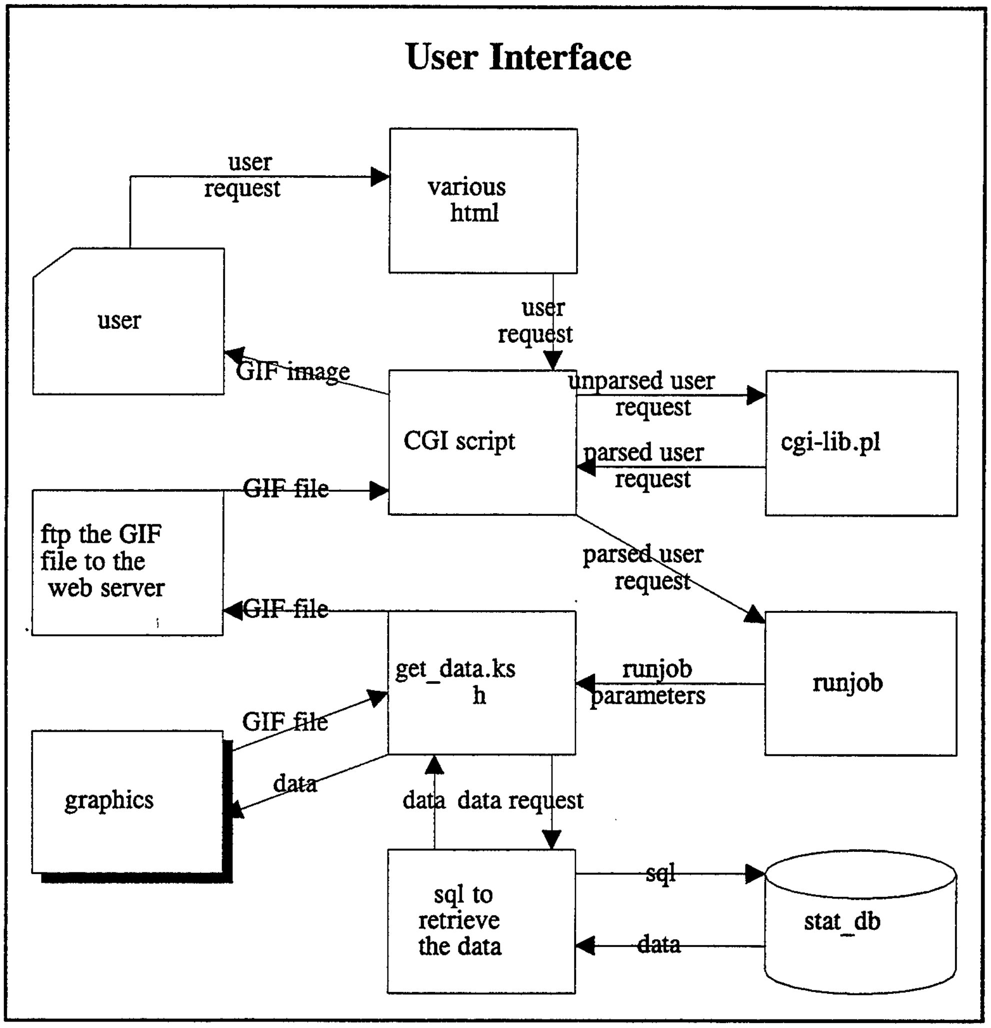
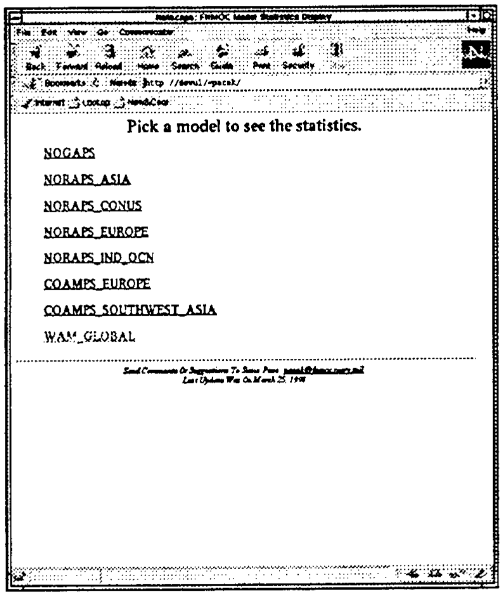


Figure 10. User Interface Design

The GUI portion has several `html forms` to interface with the users. The first model verification system web page shown in Figure 11 is created by the file *index.html*. It is shown using a `Netscape` web browser.



Pick a model to see the statistics.

NOGAPS

NORAPS_ASIA

NORAPS_CONUS

NORAPS_EUROPE

NORAPS_IND_OCN

COAMPS_EUROPE

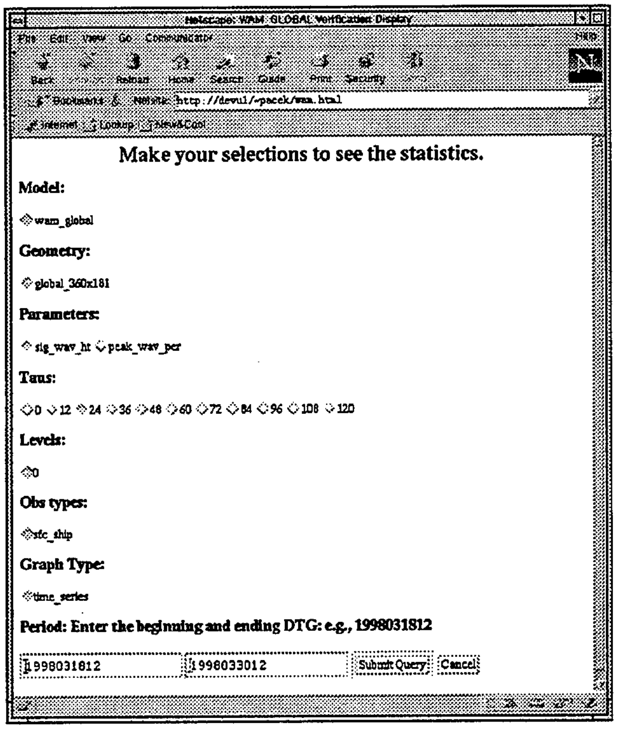
COAMPS_SOUTHWEST_ASIA

WAM_GLOBAL

Send Comments Or Suggestions To Susan Pace [illegible]
Last Update Was On March 25, 1998

Figure 11. Home Page

When the user picks a model by clicking on a selection button, the model page is displayed. An example model page is shown in Figure 12 for the WAM_GLOBAL model. This page is created by the file *wam.html*. The model pages have the default values already selected, but the users can change the values by simply clicking other choices. The user would then click on the 'Submit the query' button when (s)he is finished composing the request or the 'Cancel' button at any time.


Netscape: WAM_GLOBAL Verification Display
File Edit View Go Communicator
Help
Back
Reload
Home
Search
Guide
Print
Security
Bookmarks
Netsite: http://devul/~pacek/wam.html
Internet
Lookup
New&Cool

Make your selections to see the statistics.

Model:

◇ wam_global

Geometry:

◇ global_360x181

Parameters:

◇ sig_wav_ht ◇ peak_wav_per

Taus:

◇ 0 ◇ 12 ◇ 24 ◇ 36 ◇ 48 ◇ 60 ◇ 72 ◇ 84 ◇ 96 ◇ 108 ◇ 120

Levels:

◇ 0

Obs types:

◇ sfc_ship

Graph Type:

◇ time_series

Period: Enter the beginning and ending DTG: e.g., 1998031812

1998031812 1998033012 Submit Query Cancel

Figure 12. WAM_GLOBAL Statistics Page

Once the user submits the query, the CGI portion of this component takes over. The CGI portion has several programs to satisfy the user requests dynamically. Since this research was implemented in the current operational environment, several accommodations had to be made. The FNMOC intranet web server is on a Sun workstation called 'devul.' As discussed earlier in the *statistics database* component, the stat_db is on a database development workstation called 'div60-3.' The model statistics must be retrieved from div60-3 and transferred to devul to work in the current configuration. The GIF images are also created on div60-3 because it has better performance than devul.

When the user's request is submitted, a CGI perl script in the cgi-bin is executed to processes the user request. This CGI script parses the user request and starts the processing of the user request via runjob on div60-3. This runjob involves data retrieval from *stat_db* by Empress SQL. It then formats the retrieved data by awk for IDL to read. It executes the IDL program described in the previous section which creates a GIF file. It then transfers the GIF file to the web server via ftpbatch. Once the GIF file transfers successfully, the GIF image is displayed on the web browser.

Figure 13 shows the result of the query from Figure 12 for WAM_GLOBAL. At this point, the user can print the image, save the image in different formats supported by the web browser (e.g. GIF, postscript, etc.) or just view the image.

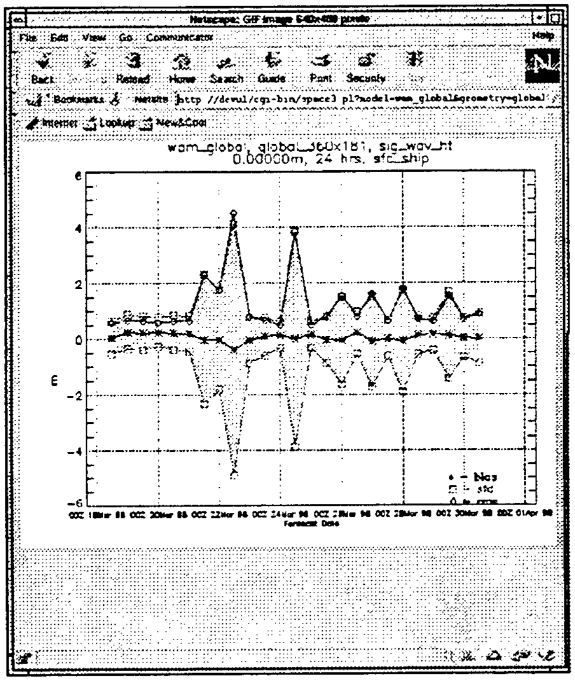

Netscape: GIF image 640x480 pixels
File Edit View Go Communicator Help
Back Reload Home Search Guide Print Security
Bookmarks Netsite: http://devul/cgi-bin/space3.pl?model=wam_global&geometry=global
Internet Lookup New&Cool
wam_global, global_360x181, sig_wav_ht
0.00000m, 24 hrs, sfc_ship
6
4
2
0
-2
-4
-6
m
00Z 18Mar 98 00Z 20Mar 98 00Z 22Mar 98 00Z 24Mar 98 00Z 26Mar 98 00Z 28Mar 98 00Z 30Mar 98 00Z 01Apr 98
Forecast Date
bias
std
rms

Figure 13. WAM_GLOBAL Statistics Graph

V. EVALUATION

The evaluation of the model verification system included alpha testing and beta testing. The alpha testing was performed by the developer by comparing the computed statistics to the existing verification system `verobs`. The beta testing was performed by FNMOC operations and FNMOC model developers (users). The operations ran the model verification system and `verobs` in parallel for four weeks. The users used the prototype to access the verification statistics via the `Netscape` web browser. The addition of a new model, `COAMPS_SOUTHWEST_ASIA`, demonstrated the ease of extending the model verification system to include other models.

A. ALPHA TESTING

Each unit (program and subroutines) of the *ops run* components was unit tested using the Fortran debugger, `TotalView`, which enabled the developer to test the binaries interactively. The debugger allows the tester to assign values to variables, print values of variables, and step through the statements in the calling program and called subroutines. This testing was useful in identifying code-level bugs, e.g., the parameter orders in the actual and formal parameter lists of the subroutine call to *boundary* in the main program *verobs* did not match.

The statistics computed by the *statistics library* subroutines were compared to the statistics computed using `Microsoft Excel`. A set of numbers from the model forecast and a set of numbers from the observational data were assigned to two arrays. The statistics bias, stdev, and rms were computed by the *statistics library* subroutines and `Excel`. These two sets of statistics matched as shown in Appendix C. The test program for the *statistics library* subroutines, *stattest*, is included in Appendix C.

The developer compared the model forecast and observational data at the first 15 latitude/longitude points of the test run of the model verification system to the first 15 latitude/longitude points of the operational `verobs` to ensure they matched point-by-point as well as the overall computed statistics. An error in the loop index in the statistics library routines was discovered and corrected during the alpha testing.

The test runs included verification of each model in its own area and the verification of the global model in the regional model areas. The purpose was to test the interpolation involved when a model was verified in an area other than its own. The global model `NOGAPS` was verified in the regional model `NORAPS` areas (Asia, Continental US, Europe, Indian Ocean) and in the `COAMPS` area (Europe). This allowed the comparison of multiple models in the same geometry. A change in one of the `COAMPS` geometries was discovered during the alpha testing. The `COAMPS` model developer modified the geometry for the model, but the verification systems were not aware of this change. The change in the geometry resulted in the job running without computing any statistics. This change was implemented in the model verification system by changing a `SMS` variable.

The *statistics database* component was tested by inserting data and performing queries against the database. The time required to return data from the initial queries was much longer than anticipated. Modifications to the database tables were made which improved query performance significantly.

A set of data from *stat_db* was saved in a text file to be the test data for the IDL program in the *graphics* component. The *graphics* component was tested by printing out the data, printing out the subarrays created from the data and examining the graphs of the model statistics. The *user interface* component was tested using the Netscape web browser. The cgi scripts were installed on the FNMOC intranet web server cgi-bin because the current web server configuration does not allow the execution of the cgi scripts in cgi-bin directory of individual users/developers. The FNMOC intranet webmaster installed the cgi scripts in the web server cgi-bin directory.

B. BETA TESTING

The purpose of the beta testing was to compare the model verification system to the existing verification process and to test the user interface of the prototype. The beta testing was performed by operations and the users at FNMOC. The operational beta testing started on 18 March 1998 by FNMOC operations to verify NOGAPS, NORAPS, COAMPS and WAM_GLOBAL models in their own areas. The verification of NOGAPS in the NORAPS and COAMPS areas was added on 25 March 1998. The model verification system was comparable to the existing verification system verobs, but it was much easier to add the verification of NOGAPS in the NORAPS and COAMPS areas.

An important part of the beta test was the evaluation of the prototypes ease of use. Generally, users indicated that the system was very easy to use. Another area examined was how easy it was to access the model statistics. Again, users evaluated this area positively. Another area evaluated was whether the system provided the required displays. For the most part this area was positively evaluated. However, the users wanted more types of graphs such as multiple models on a single chart, wanted the number of observations displayed, and better performance, i.e., faster return of the images. Based on the Beta testing results, the prototype meets the easy-to-use model verification system requirements.

C. MODIFICATION

A new model, COAMPS_SOUTHWEST_ASIA, was added to the prototype after the initial product implementation. This provided an opportunity to evaluate how easy it would be to modify the verification system. It was very easy to add the additional model to the model verification system and no design changes were required. Adding this new model required only a few modifications. The operations executes the job script *mverif.job* with appropriate SMS variables for the model (See Appendix A) after COAMPS_SOUTHWEST_ASIA completes its run. A table for COAMPS_SOUTHWEST_ASIA was created in the *stat_db*. The html forms were updated to reflect the additional model. This demonstrated that the ease of modification requirement was satisfied.

D. SUMMARY

This research has resulted in the development and demonstration of an easy-to-use model verification system for all FNMOC models. Furthermore, it has demonstrated that model verification can be standardized in FNMOC. The model verification standardization was achieved by the several components of the model verification system. The reusable statistics library standardized the statistics computation, the statistics database standardized the data format, data location, data schema, interface to the database, and the graphics standardized the graphical display of the model verification statistics. Additionally, it proved the concept of a easily modified verification system. Adding a model to the system required no design changes and no source code level changes other than adding new modules to handle the additional observation types. Finally, the prototype demonstrated that an easy to use system could be developed to return data and graphs to the user's desktop. The use of a GUI and a web browser provided the users with an easy-to-use access to the model verification statistics. No user training was required. Therefore, the research successfully addressed the research questions and has proven the concepts can be implemented in the full model verification system.

VI. RECOMMENDATIONS AND FUTURE RESEARCH

This chapter discusses the recommendations for future FNMOC model verification systems implementaion based upon the results of this research. It suggests areas of future research in fully implementing a single model verification system for FNMOC.

A. RECOMMENDATIONS

FNMOC needs to use one verification system to verify all the meterological and oceanographical models. This single system will provide many benefits to FNMOC. First a single verification system will eliminate the redundancies and inconsistencies of multiple verification systems. Additionally, it will eliminate the maintenance-intense verification systems needed to maintain data consistency and accuracy. It will also standardize the model verification process. An additional benefit is that by using the same verification system the model developers will be able to focus more on the model development effort than on the verification process. This research proved the feasibility of using a single model verification system for all the meteorological and oceanographic models at FNMOC by providing a easily modified system. This model verification system demonstrated it can verify all the models and standardize the model verifications at FNMOC and became useful to the model verification/validation group in FNMOC. This model verification system also provides a verification system for the models that do not currently have a verification systems.

FNMOC can provide users with an easy-to-use tool to access the model verification statistics that meets the users' needs. Having an easy-to-use tool that is readily assessible via the web technology is important for both internal and external users. The internal users could be the model developers, model researchers, managers, statisticians, or others in the command responsible for FNMOC data accuracy. The external users could be US Navy organizations, US Air Force organizations, or other organizations. This research proved that the concept of an easy-to-use model verification system via GUI and the web browsers is feasible. It provides access to the verification statistics and graphs to anyone who has a web browser. Giving users easy access to the model verification statistics makes their efforts to fine tune the models and/or evaluate their performance more effective. It is much too difficult and time consuming to access the information in the currently existing model verification systems in FNMOC.

FNMOC needs to document the model verification requirements for all the models. This research identified and documented each model's verification requirements. This will be useful for current and future model developers and model users both within FNMOC and outside FNMOC.

FNMOC should use prototyping as much as possible in developing new systems. The prototype was a very useful communication tool between the designer/developer of the model verification system and the users. It helped to firm up the requirements and identified additional requirements that were not identified in the initial requirements analysis, especially in the graphics area.

Finally, FNMOC should build a comprehensive model verification/validation system for all the models in FNMOC. The first step in this effort should be building a comprehensive quantitative model verification/validation system that has three subsystems. One subsystem should display the model forecast and analysis, another subsystem should display the observational data, and a final subsystem should display model verification statistics. This research dealt with the third subsystem. Each subsystem should have the same look and feel interfaces with a GUI. Addition of subject matter expertise (qualitative aspect) to aid the interpretation of the quantative measures will provide a complete model verification/validation system for all the models at FNMOC.

B. FUTURE RESEARCH

There are many potential extensions for the model verification system to implement all of the user requirements identified during the requirements analysis.

1. Ops Run

First, the new *verobs* should be completed by adding more observation types. This means adding the Fortran subroutines to read the additional observation types from the `ISIS LLT` database.

Second, more models should be added to the model verification system. There are several additional ocean models to verify, and these ocean models were prioritized for their implementation order. The observation types MCSST, Buoy and Bathy need to be read by the subroutines *mcsst_read, buoy_read, bthy_read*, respectively, for the `OTIS_GLOBAL`, `OTIS_W_ATL` and `OTIS_W_PAC` models. The next models to implement are `TOPS_GLOBAL`, `TOPS_W_ATL` and `TOPS_W_PAC` using the same observation types as

OTIS models. The users want to compare the OTIS and TOPS models and determine whether FNMOC needs to run both models. The observation type SSMI_EDI_ICE needs to be read by the subroutine *ssmi_edi_ice_read* for the PIPS_N_HEM model.

Third, the verification against the model analysis, *veranal* should be added. This involves several steps. Complete the design, using the existing verification system nogstat if feasible. Expand the *statistics database* and *user interface* components to reflect the *veranal* statistics.

2. Statistics Library

The map factor subroutine in the *statistics library* component should be revisited and completed for all the projections used at FNMOC as described in the design chapter because the map factors will be used in *veranal*. Other statistics computation modules should be added to compute the additional statistics such as anomaly correlation, probability of detection, threat score, etc.

3. Statistics Database

The *stat_db* should be incorporated into FNMOC's database and FNMOC database administrators (DBA) should be responsible for administering the stat_db. This will allow the operations to write directly into the database as the statistics are computed twice a day. This will eliminate the current method of one person transferring and populating the database manually. This will also make the latest statistics available to the users.

4. Graphics

The graphics component should be expanded by adding more types of graphs. There are many different possible graphs based on the combination of models, forecast periods, levels, observation type and statistics. Some of the combinations of interest include multiple statistics for a single model, single forecast period, single level, single observation type; multiple levels for a single model, single forecast period, single observation type, single statistic; multiple forecast periods for a single model, single level, single observation type, single statistic; multiple models for a single forecast period, single level, single observation type, single statistic. One of the users suggested adding the maps of the geometries used in the various FNMOC models and adding the number of observations on the graphs. These are very good suggestions and should be added to the system.

5. User Interface

The user interface component should be expanded to handle the various types of graphs described in the previous paragraph. The `html forms` should be made to be more robust and remove the possibility of user input errors. Currently, there is room for user input errors in the `html` forms in matching the atmospheric levels, observation types and parameters because all the levels and observation types (both surface and upper levels) are available on the forms. Here is an example scenario to demonstrate the erroneous input. Let's say the user wants to view the graph of `NOGAPS` for air_temp at the surface level. The user clicks air_temp for the parameter, 0 for the level (the correct surface level for air_temp is 2.0 meters), raob_qc for the observation type (raob_qc is not a surface level observation type). The correct selections would have been air_temp, 2 meters, and sfc_land or sfc_ship_met_qc. The users for whom this research is designed are familiar with these facts. However, this is a definite shortcoming when this model verification system's user group expands in the future.

6. Other Open Issues

The current hardware configuration in FNMOC has a severe impact on the response time in the model verification system. The intranet web server is on an older and slower workstation (devu1) while the model statistics database is on a different workstation (div60-3). This hardware configuration requires a communication (handshake) from devu1 to div60-3. The model verification system then has to use the `runjob` script to query the database and create a `GIF` image on div60-3 from devu1. Once the `GIF` image is created, another handshake from div60-3 to devu1 is needed to send the `GIF` image back to devu1 from div60-3 by `FTP`. The first handshake takes approximately one minute while the actual data query and image generations take approximately seven seconds. It takes another 1 to 2 seconds to transfer the `GIF` file. The delays associated with the handshakes, `runjob` and `ftp` could be eliminated if the database and web server were on a single, faster workstation. The specific hardware requirements for a single server for web, database, and graphics need to be identified. Having hardware with the appropriate capability would also ease the development and testing process. It would eliminate the need for various routines such as `runjob` and `ftp`. This would decrease the time needed to process the user request by eliminating the need for the various hardware systems to communicate with each other. Finally, this would also help in planning for the future installation of the model verification system on the internet for external users.

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APPENDIX A

A. SMS VARIABLES

The following are common SMS variables for all the models:

```
ISIS_INIT=/a/ops/isis/db_init/init_ops.ksh
OPSPATH=/a/ops
OPSBIN=/a/ops/bin
CRDATE=$(dtg)
```

1. NOGAPS

```
TAUI=0
TAUE=144
TAUINC=12
GEOMNM1=global_360x181
GEOMNM2=global_360x181
ISIS_TABLE=NOGAPS
VERIF_SOURCE=obs
```

2. NORAPS_ASIA

```
TAUI=0
TAUE=48
TAUINC=12
GEOMNM1=asia_nest1_appl
GEOMNM2=asia_nest1_appl
ISIS_TABLE=NORAPS_ASIA
VERIF_SOURCE=obs
```

3. NORAPS_CONUS

```
TAUI=0
TAUE=48
TAUINC=12
GEOMNM1=conus_nest1_appl
GEOMNM2=conus_nest1_appl
ISIS_TABLE=NORAPS_CONUS
VERIF_SOURCE=obs
```

4. NORAPS_EUROPE

```
TAUI=0
TAUE=48
TAUINC=12
GEOMNM1=europe_nest1_appl
GEOMNM2=europe_nest1_appl
ISIS_TABLE=NORAPS_EUROPE
VERIF_SOURCE=obs
```

5. NORAPS_IND_OCN

```
TAUI=0
TAUE=48
TAUINC=12
GEOMNM1=ind_ocn_nest1_appl
GEOMNM2=ind_ocn_nest1_appl
ISIS_TABLE=NORAPS_IND_OCN
VERIF_SOURCE=obs
```

6. NOGAPS FOR ASIA

```
TAUI=0
TAUE=48
TAUINC=12
GEOMNM1=global_360x181
GEOMNM2=asia_nest1_appl
ISIS_TABLE=NOGAPS
VERIF_SOURCE=obs
```

7. NOGAPS FOR CONUS

```
TAUI=0
TAUE=48
TAUINC=12
GEOMNM1=global_360x181
GEOMNM2=conus_nest1_appl
ISIS_TABLE=NOGAPS
VERIF_SOURCE=obs
```

8. NOGAPS FOR EUROPE

```
TAUI=0
```

```
TAUE=48
TAUINC=12
GEOMNM1=global_360x181
GEOMNM2=europe_nest1_appl
ISIS_TABLE=NOGAPS
VERIF_SOURCE=obs
```

9. NOGAPS FOR EUROPE_NEST2

```
TAUI=0
TAUE=48
TAUINC=12
GEOMNM1=global_360x181
GEOMNM2=europe_nest2_appl2
ISIS_TABLE=NOGAPS
VERIF_SOURCE=obs
```

10. NOGAPS FOR EUROPE_NEST3

```
TAUI=0
TAUE=24
TAUINC=6
GEOMNM1=global_360x181
GEOMNM2=europe_nest3_appl3
ISIS_TABLE=NOGAPS
VERIF_SOURCE=obs
```

11. COAMPS_EUROPE

```
TAUI=0
TAUE=48
TAUINC=12
GEOMNM1=europe_nest2_appl2
GEOMNM2=europe_nest2_appl2
ISIS_TABLE=COAMPS_EUROPE
VERIF_SOURCE=obs
```

12. COAMPS_EUROPE FOR NEST3

```
TAUI=0
TAUE=24
TAUINC=6
GEOMNM1=europe_nest3_appl3
```

```
GEOMNM2=europe_nest3_appl3
ISIS_TABLE=COAMPS_EUROPE
VERIF_SOURCE=obs
```

13. COAMPS_SOUTHWEST_ASIA FOR NEST2

```
TAUI=0
TAUE=48
TAUINC=12
GEOMNM1=southwest_asia_nest2_appl
GEOMNM2=southwest_asia_nest2_appl
ISIS_TABLE=COAMPS_SOUTHWEST_ASIA
VERIF_SOURCE=obs
```

14. COAMPS_SOUTHWEST_ASIA FOR NEST3

```
TAUI=0
TAUE=24
TAUINC=6
GEOMNM1=southwest_asia_nest3_appl
GEOMNM2=southwest_asia_nest3_appl
ISIS_TABLE=COAMPS_SOUTHWEST_ASIA
VERIF_SOURCE=obs
```

15. WAM_GLOBAL

```
TAUI=0
TAUE=144
TAUINC=12
GEOMNM1=global_360x181
GEOMNM2=global_360x181
ISIS_TABLE=WAM_GLOBAL
VERIF_SOURCE=obs
```

B. NAMELIST REQUIREMENTS OBTAINED FROM THE USERS FOR EACH MODEL

Table 3. Namelist information obtained from the users for each model

WAM_GLOBAL										
parm	typlvl	units	lvl_1	dsetname	llt parm	llt dsetname	llt seq_type	qc flag	obs time window	llt header file
sig_wav_ht	surface	m	0	fcst_ops	inst_wav_ht_2	decoded	sfc_ship	none	+/-12	SFC_SHIP.H
sig_wav_ht	surface	m	0	fcst_ops	sig_wav_ht	satdat	alty	none	+/-12	ALTY.H
peak_wav_per	surface	s	0	fcst_ops	inst_wav_per	decoded	sfc_ship		+/-12	SFC_SHIP.H

PIPS_N_HEM										
parm	typlvl	units	lvl_1	dsetname	llt parm	llt dsetname	llt seq_type	qc flag	obs time window	llt header file
ice_cvrg	surface	fraction	0	fcst_ops	ice_conc	decoded	ssmi_edr_ice	none	+/-12	SSMI_EDI_ICE
sea_temp	surface	deg_K	0	fcst_ops	sea_temp	decoded	mcsst	sea_temp_qc_id	+/-12	MCSST.H

OTIS_GLOBAL

parm	typlvl	units	lvl_1	dsetname	llt parm	llt dsetname	llt seq_type	qc flag	obs time window	llt header file
sea_temp	surface	deg_K	0	anal_ops	sea_temp	decoded	mcsst	sea_temp_qc_id	+/-12	MCSST.H
sea_temp	surface	deg_K	0	anal_ops	sea_temp	metoc_qc	buoy	pos_qc_id, sea_temp_qc_id	+/-12	BUOY.H
sea_temp	surface	deg_K	0	anal_ops	sea_temp	metoc_qc	sfc_ship	pos_qc_id, sea_temp_qc_id	+/-12	SFC_SHIP.H
sea_temp	surface	deg_K	0	anal_ops	sea_temp	metoc_qc	bthy	pos_qc_id, sea_temp_qc_id	+/-12	BTHY.H

OTIS_W_ATL

parm	typlvl	units	lvl_1	dsetname	llt parm	llt dsetname	llt seq_type	qc flag	obs time window	llt header file
sea_temp	dpth_sfc	deg_K	0	anal_ops	sea_temp	metoc_qc	bthy		+/-12	BTHY.H

OTIS_W_PAC

parm	typlvl	units	lvl_1	dsetname	llt parm	llt dsetname	llt seq_type	qc flag	obs time window	llt header file
sea_temp	dpth_sfc	deg_K	0	anal_ops	sea_temp	metoc_qc	bthy	pos_qc_id, sea_temp_qc_id	+/-12	BTHY.H

TOPS_GLOBAL

parm	typlvl	units	lvl_1	dsetname	llt parm	llt dsetname	llt seq_type	qc flag	obs time window	llt header file
sea_temp	dpth_sfc	deg_K	0	fcst_ops	sea_temp	metoc_qc	bthy		+/-12	BTHY.H

TOPS_W_ATL

parm	typlvl	units	lvl_1	dsetname	llt parm	llt dsetname	llt seq_type	qc flag	obs time window	llt header file
sea_temp	dpth_sfc	deg_K	0	fcst_ops	sea_temp	metoc_qc	bthy		+/-12	BTHY.H

TOPS_W_PAC

parm	typlvl	units	lvl_1	dsetname	llt parm	llt dsetname	llt seq_type	qc flag	obs time window	llt header file
sea_temp	dpth_sfc	deg_K	0	fcst_ops	sea_temp	metoc_qc	bthy		+/-12	BTHY.H

NOGAPS, ALL NORAPS, ALL COAMPS

parm	typlvl	units	lvl_1	dsetname	llt parm	llt dsetname	llt seq_type	qc flag	obs time window	llt header file
air_temp	isbr_lvl	deg_K	*	fcst_ops	air_temp	fnmoc	raob_qc	air_temp_qc_id		RAOB_QC.H
air_temp	ht_sfc	deg_K	2.0	fcst_ops	air_temp	fnmoc	sfc_ship_met_qc	air_temp_qc_id		SFC_SHIP_MET_QC.H
air_temp	ht_sfc	deg_K	2.0	fcst_ops	air_temp	fnmoc	sfc_lnd	air_temp_qc_id		SFC_LND.H
geop_ht	isbr_lvl	gpm	*	fcst_ops	geop_ht	fnmoc	raob_qc	geop_ht_qc_id		RAOB_QC.H
pres	msl	mb	0.0	fcst_ops	sea_lvl_pres	fnmoc	sfc_ship_met_qc	sea_lvl_pres_qc_id		SFC_SHIP_MET_QC.H
pres	msl	mb	0.0	fcst_ops	sea_lvl_pres	fnmoc	sfc_lnd	sea_lvl_pres_qc_id		SFC_LND.H

NOGAPS, ALL NORAPS, ALL COAMPS										
wnd_spd	isbr_lvl	m/s	*	fcst_ops	wnd_spd	fnmoc	raob_qc	wnd_qc_id		RAOB_QC.H
wnd_spd	ht_sfc	m/s	19.5	fcst_ops	wnd_spd	fnmoc	sfc_lnd	wnd_qc_id		SFC_LND.H
wnd_spd	ht_sfc	m/s	19.5	fcst_ops	wnd_spd	fnmoc	sfc_ship_met_qc	wnd_qc_id		SFC_SHIP_MET_QC..H

* 1000, 925, 850, 700, 500, 400 300, 250, 200, 150, 100

C. NON-SURFACE NAMELIST FILES

1. NOGAPS, all NORAPS and all COAMPS

```
&verlst
 parm="air_temp", "geop_ht", "wnd_spd",
 dsetname="fcst_ops","fcst_ops","fcst_ops",
 obs_parm="air_temp", "geop_ht", "wnd_spd",
 odsetname="fnmoc","fnmoc","fnmoc",
 units="deg_K","gpm", "m/s",
 lvltype="isbr_lvl","isbr_lvl","isbr_lvl",
 obstype="raob_qc","raob_qc","raob_qc",
 level=1000,925,850,700,500,400,300,250,200,150,100,
 stats="bias","rms","std",
 tval=35.0
&end
```

D. SURFACE NAMELIST FILES

1. NOGAPS, all NORAPS and all COAMPS

```
&sfclst
sfc_parm="air_temp","air_temp", "pres","pres", "wnd_spd","wnd_spd",
sfc_dsetname="fcst_ops","fcst_ops","fcst_ops","fcst_ops","fcst_ops","fcst_ops",
sfc_obs_parm="air_temp","air_temp", "sea_lvl_pres","sea_lvl_pres","wnd_spd", "wnd_spd",
sfc_odsetname="fnmoc","fnmoc","fnmoc","fnmoc","fnmoc","fnmoc",
sfc_units="deg_K","deg_K","mb","mb","m/s", "m/s",
sfc_lvltype="ht_sfc","ht_sfc", "msl","msl","ht_sfc","ht_sfc",
sfc_obstype="sfc_lnd","sfc_ship_met_qc","sfc_lnd","sfc_ship_met_qc","sfc_lnd","sfc_ship
_met_qc",
sfc_level=2.0,2.0,0.0,0.0, 19.5,19.5,
sfc_stats="bias","rms","std",
sfc_tval=35.0
&end
```

2. WAM_GLOBAL

```
&verlst
 parm="sig_wav_ht", "peak_wav_per",
 obs_parm="inst_wav_ht_2", "inst_wav_per",
 units="m", "s",
 lvltype="surface","surface",
 level=0,0,
 stats="bias","rms","std",
 obstype="sfc_ship",
 tval=35.0
&end
```

APPENDIX B SOURCE CODE

A. OPS RUN

1. mverif.job

```
# QSUB -lt 00:30:00
# QSUB -lT 00:30:00
# QSUB -lm 10Mw
# QSUB -lM 10MW
# QSUB -eo
# QSUB -ko
# QSUB -o /home/pacek/mverif/etc/mverif.out
# QSUB -s /bin/ksh
# QSUB -x

#==========================================================================
# local function to handle the exit code from executing binary
#==========================================================================
INIT_user_exit() {

  case $? in
   0) #Normal exit
     INIT_joblog_comment=MVERIF_COMPLETED_OK
     code=0
     ;;
   1) #pfxgetenv error in the main program
     INIT_joblog_comment=MVERIF_INFORMATIVE_PFXGETENV_ERROR
     code=0
     ;;
   2) #ch2int error in the main program
     INIT_joblog_comment=MVERIF_INFORMATIVE_CH2INT_ERROR
     code=0
     ;;
   3) #not enough info to continue
     INIT_joblog_comment=MVERIF_INFORMATIVE_NOT_ENOUGH_INFO
     code=0
     ;;
   4) #output file open error
     INIT_joblog_comment=MVERIF_INFORMATIVE_OUTPUT_FILE_OPEN_ERR
     code=0
     ;;
   5) #error with ggrd call
     INIT_joblog_comment=MVERIF_INFORMATIVE_GGRD_CALL_ERR
     code=0
     ;;
   6) #error with getgeom call
```

```
     INIT_joblog_comment=MVERIF_INFORMATIVE_GETGEOM_CALL_ERR
     code=0
     ;;
   7) #error with boundary subroutine call
     INIT_joblog_comment=MVERIF_INFORMATIVE_BOUNDARY_CALL_ERR
     code=0
     ;;
   *) #Abnormal exit, save log file
     INIT_joblog_comment=MVERIF_FAILED
     code=99
     if [ -f "$tempfile" ]; then
       cp $tempfile $HOME/mverif/etc/o_mverif_err.log
     fi
     ;;
  esac
  return $code
}

#==================================================================
# setup the job environment
#==================================================================
. $OPSBIN/init_job
set -Sx
INIT_do_not_notify_operator=0
INIT_notify_status=ERR
INIT_notify_users="pacek"
. $ISIS_INIT

#==================================================================
# test to see if env var CRDATE exist, otherwise take the ops dtg
#==================================================================
if [ -z "$CRDATE" ]
  then
    echo "Null CRDATE, setting to ops dtg."
    CRDATE=$(dtg)
    export CRDATE
fi

#==================================================================
# set the required env var and export the SMS and other var
#==================================================================
#PROGBIN=/home/pacek/mverif/bin
PROGBIN=${PROGBIN:-$OPSBIN}
MVERIF_DIR=$OPSPATH/etc/dynamic/app/mverif
#MVERIF_DIR=$HOME/mverif/etc
echo $MVERIF_DIR
integer TAUI
integer TAUE
integer TAUINC
export TAUI TAUE TAUINC
#TEST_DIR=/home/pacek/mverif/test
TEST_DIR=$OPSPATH/etc/static/app/mverif
```

```
NAMLIST_FILE1=$ISIS_TABLE-verfil
NAMLIST_FILE2=$ISIS_TABLE-sfcverfil
print "namlist_file1=" $NAMLIST_FILE1 " namlist_file2=" $NAMLIST_FILE2
export NAMLIST_FILE1 NAMLIST_FILE2

#==========================================================================
# job accounting info
#==========================================================================
ja

#==========================================================================
# need to pull out the month and year from CRDATE
#==========================================================================
year=`echo $CRDATE | cut -c1-4`
month=`echo $CRDATE | cut -c5-6`
case $month in
  01) mon='jan' ;;
  02) mon='feb' ;;
  03) mon='mar' ;;
  04) mon='apr' ;;
  05) mon='may' ;;
  06) mon='jun' ;;
  07) mon='jul' ;;
  08) mon='aug' ;;
  09) mon='sep' ;;
  10) mon='oct' ;;
  11) mon='nov' ;;
  12) mon='dec' ;;
esac

#==========================================================================
# find the appropriate subdirectory
#==========================================================================
subdir=$mon$year

#==========================================================================
# need to test for the existance of subdir otherwise the
# job will crash
#==========================================================================
if [ -d $MVERIF_DIR/$subdir ]
then
  echo $MVERIF_DIR/$subdir "exists"
else
  mkdir $MVERIF_DIR/$subdir
  chmod 775 $MVERIF_DIR/$subdir
fi

#==========================================================================
# the output directory
#==========================================================================
OUTDIR=$MVERIF_DIR/$subdir
echo $ISIS_TABLE $TAUI $TAUE $TAUINC
```

```
#==========================================================================
# determine the current watch and month's stat file name
#==========================================================================
curr_file=$ISIS_TABLE$GEOMNM1$CRDATE
month_file=$ISIS_TABLE$GEOMNM1$mon$year
if [[ $GEOMNM2 != '' ]]
then
  curr_file=$ISIS_TABLE$GEOMNM2$CRDATE
  month_file=$ISIS_TABLE$GEOMNM2$mon$year
fi

#==========================================================================
# if curr_file exists (ran once) delete so program will not exit
#==========================================================================
if [ -f $OUTDIR/$curr_file ]
  then
       echo "removing stat out file"
       rm $OUTDIR/$curr_file
fi

#==========================================================================
# to use $TMPDIR, the scratch area
#==========================================================================
cd $TMPDIR

#==========================================================================
# copy the namelist files to the scratch area
#==========================================================================
if [[ -f $TEST_DIR/$NAMLIST_FILE1 ]]
then
  cp $TEST_DIR/$NAMLIST_FILE1 $NAMLIST_FILE1
fi

if [[ -f $TEST_DIR/$NAMLIST_FILE2 ]]
then
  cp $TEST_DIR/$NAMLIST_FILE2 $NAMLIST_FILE2
fi

#==========================================================================
# execute mverif program
#==========================================================================
if [[ $VERIF_SOURCE = 'obs' ]]
then
  print "calling verobs"
  $PROGBIN/verobs
elif [[ $VERIF_SOURCE = 'anal' ]]
then
  print "calling veranal"
  $PROGBIN/veranal
else
  print "VERIF_SOURCE must be either 'obs' or 'anal'."
  exit 8
```

```
fi

#==========================================================================
# append the current run's stat to the monthly stat file
#==========================================================================
#cp $curr_file $OUTDIR/$curr_file
cat $curr_file >> $OUTDIR/$month_file

#==========================================================================
# close up the job accounting info and clean up
#==========================================================================
rm -f core
ja -st

#.................START EPILOGUE.....................................
#
# SCCS IDENTIFICATION:  @(#)mverif.job 1.1 04/24/98 /h/cm/library/mverif/src/job/mverif.job_v
#
# CONFIGURATION IDENTIFICATION:
#
# SCRIPT NAME:  mverif.job
#
# SHELL TYPE:  Korn
#
# DESCRIPTION:  Script that runs MVERIF which computes verifying stats of
#           the models against the LLT observations or VERANAL which
#           computes verifying stats against the model analysis.
#
# COPYRIGHT:      (c) 1998 FLENUMMETOCCEN
#                 U.S. GOVERNMENT DOMAIN
#                 ALL RIGHTS RESERVED
#
# CONTRACT NUMBER AND TITLE: NONE
#
# REFERENCES: NONE
#
# CLASSIFICATION: Unclassified
#
# RESTRICTIONS: NONE
#
# COMPUTER/OPERATING SYSTEM      Cray UNICOS
# DEPENDENCIES:
#
# LIBRARIES OF RESIDENCE: /a/ops/app/mverif/src/job
#
# USAGE: qsub mverif.job
#
# PARAMETERS: SMS variables needed
#    Name             Description
# --------       ------------------------
# ISIS_INIT       ISIS init script
# CRDATE           current run dtg
# OPSPATH        ops path
# OPSBIN        binary directory
# PROGBIN        test binary directory
# MVERIF_DIR      mverif stat output files directory
# GEOMNM1         geometry name (e.g., conus_nest1_appl)
# GEOMNM2         geometry name to interpolate to
# ISIS_TABLE      model name (e.g., NORAPS_CONUS)
# TAUI          starting tau
# TAUE          finishing tau
# TAUINC         tau increment
#
# RETURN CODE:
#
# FILES:
#   Name        Usage       Description
# -----------   ------    ------------------------
# curr_file      IN        file that contains the current run's stats
# month_file      IN/OUT     file that contains the month's stats
#
# DATA BASES:
#   Name       Table     Usage   Description
#  --------    ----------- ------ ----------------------------
#
# NON-FILE INPUT/OUTPUT:
#   Name     Type     Usage       Description
#  --------  -----------   ------   -------------------------
#
# ERROR CONDITIONS:
#      Condition                  Action
# ------------------------    -----------------------------------
#   data not found            stop executing
#   curr_file not found         cannot append to month_file,
#                          sends an email to group
# ADDITIONAL COMMENTS: NONE
#
#.................MAINTENANCE SECTION................................
#
# EXTERNALS CALLED:
#       Name          Description
#     ----------   -----------------------------------------
#     verobs     reads ISIS grid data, ISIS LLT data and computes
#              the models' verifying stats
#     veranal    reads model forecast and analysis from ISIS grid
#              and computes the models' verifying stats
#
# VARIABLES:
#       Name              Description
#     --------        ---------------------------------
#     year          4-digit year from $CRDATE
#     month           2-digit month from $CRDATE
#     mon           3-character month (e.g., jan)
#     NAMELIST_FILE1     namelist file name for upper levels
#       NAMELIST_FILE2      namelist file name for surface level
#
# METHOD: change directory to the $TMPDIR and run the Fortran program
#       verobs or veranal, copy the current run's stat file to the
#       $OPSPATH and append the current run's stat file to the
#       monthly stat file in the $OPSPATH
#
# RECORD OF CHANGES:
# <<CHANGE NOTICE>> version 1.1 (29 Apr 1998) -- Kyongsuk Pace
#    initial submission
#
#..................END EPILOGUE....................................
```

2. statupd.ksh

```
#!/bin/ksh
#==================================================================
# inserts the model stats into the stat_db
#==================================================================
DATA_DIR=/home/pacek/data
DB_DIR=/d/model-stats
cd $DB_DIR

#==================================================================
# field separation for Empress
#==================================================================
export MSVALSEP=' '

#==================================================================
# is there a new data file? if so, move them
#==================================================================
if [[ -a $DATA_DIR ]]
then
  mv $DATA_DIR/* .
else
  print "There are no data files!"
fi

#==================================================================
# determine which model by looking at the files that
# ends with numeric 0 or 2
# example: NOGAPSglobal_360x1811998021000
#==================================================================
for OBJ in *[0-9]
do
  print $OBJ
  awk '/^[0-9]+/ { print $1,$2,$3,$4,$5,$6,$7,$8,$9,$10,$11,$12 }' \
  $OBJ > tmp

  case $OBJ in
    NOGAPSasia_nest1_appl*)
```

```
      empcmd stat_db "insert into nogaps_asia_nest1_appl from tmp;";;
    NOGAPSconus_nest1_appl*)
      empcmd stat_db "insert into nogaps_conus_nest1_appl from tmp;";;
    NOGAPSeurope_nest1_appl*)
      empcmd stat_db "insert into nogaps_europe_nest1_appl from tmp;";;
    NOGAPSeurope_nest2_appl2*)
      empcmd stat_db "insert into nogaps_europe_nest2_appl2 from tmp;";;
    NOGAPSeurope_nest3_appl3*)
      empcmd stat_db "insert into nogaps_europe_nest3_appl3 from tmp;";;
    NOGAPSglobal*)
      empcmd stat_db "insert into nogaps_global_360x181 from tmp;";;
    NOGAPSind_ocn_nest1_appl*)
      empcmd stat_db "insert into nogaps_ind_ocn_nest1_appl from tmp;";;
    NORAPS_ASIA*)
      empcmd stat_db "insert into noraps_asia from tmp;";;
    NORAPS_CONUS*)
      empcmd stat_db "insert into noraps_conus from tmp;";;
    NORAPS_EUROPE*)
      empcmd stat_db "insert into noraps_europe from tmp;";;
    NORAPS_IND_OCN*)
      empcmd stat_db "insert into noraps_ind_ocn from tmp;";;

    COAMPS_SOUTHWEST_ASIA*)
      empcmd stat_db "insert into coamps_sw_asia from tmp;";;
    COAMPS_EUROPE*)
      empcmd stat_db "insert into coamps_europe from tmp;";;
    WAM_GLOBAL*)
      empcmd stat_db "insert into wam_global from tmp;";;
    *)
      print "no stat table for " $OBJ;;
  esac

  mv $OBJ /home/pacek/backup
done
```

3. v_data.h

```
!............................START PROLOGUE...........................
!
! SCCS IDENTIFICATION:  @(#)v_data.h   1.1 04/24/98
!
! RECORD OF CHANGES:
! <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
!    Initial submission
!
!............................END PROLOGUE............................

!************************************************************
!The Fortran include file V_DATA will hold all the data definitions
!used throughout the verobs and its subroutines.  This will
!help in modifying at one point if the requirement happens to
```

```
!change in the future.
!**********************************************************
    integer     :: im
    integer     :: jm
    integer     :: ijmax    ! 1-dim array max size
    integer     :: maxobs   ! max num of obs
    integer     :: maxprm   ! max num of parameters to verify
    integer     :: maxstat  ! max num of stats to verify
    integer     :: maxtvl   ! max num of threshhold values
    integer     :: maxlvl   ! max num of levels
    integer     :: size
    real        :: bad_value ! value for missing or bad data
    real        :: check_val ! ISIS missing value checking number

    parameter(im=360)
    parameter(jm=181)
    parameter(ijmax=im*jm)
    parameter(maxobs=50000)
    parameter(maxprm=20)
    parameter(maxstat=10)
    parameter(maxtvl=20)
    parameter(maxlvl=30)
    parameter(size=5000)
    parameter(bad_value=1.E+10)
    parameter(check_val=1.E+9)

    !------------------
    ! env var
    !------------------
    character(16) :: crdate_val  ! current run dtg value
    character(8)  :: taui_val    ! starting tau value
    character(8)  :: taue_val    ! ending tau value
    character(8)  :: tauinc_val  ! tau increment value
    character(32) :: modelname   ! model name value
    character(32) :: geomname    ! geometry name value
    character(24) :: prjnnm      ! projection name
    character(16) :: vdtg        ! verifying dtg, also for write
    integer       :: ngeom       ! C pointer for the given geomname
    integer       :: ncols       ! number of columns
    integer       :: nrows       ! number of rows
    integer       :: itaui       ! integer beginning tau
    integer       :: itaue       ! integer ending tau
    integer       :: itauinc     ! integer tau increment
```

4. verobs.f90

```
    program verobs
C
C.............................START PROLOGUE............................
C
CSCCS IDENTIFICATION: @(#)verobs.f901.1 04/24/98 /h/cm/library/mverif/src/main/verobs.f90_v
```

```
C
C CONFIGURATION IDENTIFICATION:   NONE
C
C MODULE NAME:  verobs
C
C DESCRIPTION: This program verifies the model forecast fields against
C          observations for various models.
C
C COPYRIGHT:              (c) 1998 FLENUMMETOCCEN
C                    U.S. GOVERNMENT DOMAIN
C                    ALL RIGHTS RESERVED
C
C CONTRACT NUMBER AND TITLE:  N/A
C
C REFERENCES: previous verobs.f
C
C CLASSIFICATION:  Unclassified
C
C RESTRICTIONS:  NONE
C
C COMPUTER/OPERATING SYSTEM
C          DEPENDENCIES:  Cray UNICOS
C
C LIBRARIES OF RESIDENCE:  /a/ops/bin
C
C USAGE: Korn shell script mverif.job
C
C PARAMETERS: N/A
C
C COMMON BLOCKS:  N/A
C
C FILES:
C    Name      Unit   Type   Attribute  Usage      Description
C  ----------   ---- -------- --------- -------  -----------------
C  $MODEL-verfil 10   FORMATTED DIRECT    IN     Contains parameter, stat
C                                 types to compute
C  $MODEL-sfcverfil 10  FORMATTED DIRECT    IN     Contains parameter, stat
C                                 types to compute for sfc
C  MODELGEOMDTG  10   FORMATTED DIRECT    OUT   Contains the computed stats
C  (e.g., NORAPSconus_nest1_appl1996010100)        for each run
C
C DATA BASES:
C    Name          Table      Usage          Description
C  ----------    -------------- ---------   ------------------------
C  ISIS Grid data  Various       IN      Model Forecasts
C  ISIS LLT data   Various       IN      Observed environmental data
C
C NON-FILE INPUT/OUTPUT: N/A
C
C ERROR CONDITIONS:
C      CONDITION             ACTION
C   ----------------      ---------------------------
```

```
C    no env variables       exit with code 1
C    err in char to integer
C    conversion             exit with code 2
C    empty input arrays     exit with code 3
C    err opening output file  exit with code 4
C    ggrd error             exit with code 5
C    getgeom error          exit with code 6
C    boundary error         exit with code 7
C    no ISIS Grid data      stop executing
C    no ISIS LLT data       stop executing
C
C ADDITIONAL COMMENTS:   NONE
C
C...................MAINTENANCE SECTION................................
C
C MODULES CALLED:
C       Name        Description
C       -------     ----------------------
C       BOUNDARY     Computes min/max lat/lon for reading obs from LLT DB
C       CH2INT       Converts character to integer
C       DBSTOP       ISIS software that terminates database
C       DTGMOD       FNOC utility that increments a DTG
C       EXIT         System call that exits program
C       LLTREAD      Reads obs from LLT DB
C       PXFGETENV    Gets environment variable
C       GETGEOM      Gets geometry arguments to be used by other routines
C       GGRD         Returns ISIS info. on given geometry
C       GRD          Reads gridded fcst fields from ISIS
C       STRLEN       FORTRAN function that returns string length
C       F2OB         Interpolates fcst to obs pts
C       UV2DF        Converts wind u/v to direction and speed
C
C LOCAL VARIABLES AND       Structures are documented in detail
C        STRUCTURES:        where they are defined in the code
C                           within include files.
C
C INCLUDE FILES:
C     Name                  Description
C   ---------------   ------------------------------------------------
C
C COMPILER DEPENDENCIES: empef90
C
C COMPILE OPTIONS:  -f fixed -c
C
C MAKEFILE: Located at /a/ops/app/mverif/src/main/Makefile
C         UNICOS make
C
C RECORD OF CHANGES:
C <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
C    Initial submission
C
C.............................END PROLOGUE............................
```

```
C
   implicit none
   include 'v_data.h'

c***********************************************************************
c  Local variables
c***********************************************************************
   ! record type
   TYPE ver_data
     character(32) :: param
     character(24) :: dsetnm
     character(32) :: obs_param
     character(24) :: odsetnm
     character(32) :: unit
     character(24) :: typlvl
     real          :: lvl_1
     character(24) :: obs_type
   END TYPE ver_data

c***********************************************************************
   !array of records
c***********************************************************************
   TYPE (ver_data) verif(maxprm*maxlvl),
  2               sfc_verif(maxprm)

   character(1) :: cnul !one blank space var used to initialize
   character(8) :: seclvl !secret level returned from GRD
   character(10):: dtg  !10 char long crdate_val
   character(16):: cdtg !dtgmod applied dtg, i.e. dtg-0,12,24, etc.
   character(16):: tdtg !temp cdtg
   character(16):: stats(maxstat), sfc_stats(maxstat) !stat types
   character(24):: stdesc !storage description returned from GETGEOM
   character(24):: lvltype(maxprm), sfc_lvltype(maxprm)!level types
   character(24):: obstype(maxprm), sfc_obstype(maxprm)
              !llt seq type (raob_qc, sfc_ship, etc.)
   character(24):: dsetname(maxprm), sfc_dsetname(maxprm)
   character(24):: odsetname(maxprm), sfc_odsetname(maxprm)
   character(32):: parm(maxprm), sfc_parm(maxprm) !parameters
   character(32):: obs_parm(maxprm), sfc_obs_parm(maxprm)
   character(32):: units(maxprm), sfc_units(maxprm)
   character(32):: geomname2, outgeomname
   character(60):: outstats !output filename
   character(40):: namlist_file1_val, namlist_file2_val
   character(80):: title
   character(4) :: nul_geom

   integer    :: nstat, nparm, nobs, nobstype, nlevel
   integer    :: sfc_nstat, sfc_nparm, sfc_nobs, sfc_nobstype
   integer    :: arr_size, sfc_arr_size

   integer    :: ktau, ltau, lstat, i, j, k, l, m, n
   integer    :: numchar, istat
```

```
      integer     :: id, iseq, status

      integer     :: lenMODEL, lenmodelname
      integer     :: lenGEOMNM, lengeomname
      integer     :: lenGEOMNM2, lengeomname2
      integer     :: lenTAUI, lentaui_val
      integer     :: lenTAUE, lentaue_val
      integer     :: lenTAUINC, lentauinc_val
      integer     :: lenCRDATE, lencrdate_val
      integer     :: lenNAMLIST_FILE1, lennamlist1_val
      integer     :: lenNAMLIST_FILE2, lennamlist2_val

      real     :: fcst(ijmax), fcstu(ijmax), fcstv(ijmax)
      real     :: fcst2(ijmax), fcstu2(ijmax), fcstv2(ijmax)
      real     :: fu(ijmax), fv(ijmax), fdir(maxobs)
      real     :: oblat(maxobs), oblon(maxobs), obval(maxobs)
      real     :: newlat(maxobs), newlon(maxobs), newobs(maxobs)
      real     :: fob(maxobs)
      real     :: newfob(maxobs)
      real     :: newfu(ijmax), newfv(ijmax)
      real     :: level(maxlvl), sfc_level(maxlvl)
      real     :: origx, origy, parm1, parm2, parm3, xintdis,
     2            yintdis, minlat, maxlat, minlon, maxlon
      real     :: xlvl, level_2, paknul
      real     :: tval, sfc_tval
      real     :: bias, rms, std, ancor
      real     :: ftau !float tau

      double precision :: origlat, origlon

c***********************************************************************
c   Function
c***********************************************************************
      integer strlen

c***********************************************************************
c   Data Initialization
c***********************************************************************

      data cnul   /' '/
      data lstat /10/
      data paknul /10.e10/
      data level_2 /0.0/

c***********************************************************************
c   Namelists
c***********************************************************************
      namelist /verlst/ parm, dsetname, obs_parm, odsetname,
     2    units, lvltype, obstype, level, stats, tval

      namelist /sfclst/ sfc_parm, sfc_dsetname, sfc_obs_parm,
     2    sfc_odsetname, sfc_units, sfc_lvltype,
     2     sfc_obstype, sfc_level, sfc_stats, sfc_tval

c************************************************************************
c   initialize some var
c************************************************************************
      crdate_val(1:16) = cnul
      dtg(1:10) = cnul
      cdtg(1:16) = cnul
      seclvl = 'UNCLASS'

c************************************************************************
c   Get the environment variables that are set in the job script,
c   CRDATE, TAUS, TAUE, TAUINC, MODEL, GEOMNM, DATASET1, DATASET2,
c   NAMLIST_FILE1 and NAMLIST_FILE2.
c************************************************************************
      namlist_file1_val = cnul
      namlist_file2_val = cnul
      geomname2 = cnul

      CALL PXFGETENV('ISIS_TABLE', lenMODEL, modelname, lenmodelname,
     2          istat)
      if (istat .ne. 0) then
        write *, "MODEL is unspecified"
        CALL EXIT(1)
      end if

      CALL PXFGETENV('GEOMNM1', lenGEOMNM, geomname, lengeomname,
     2          istat)
      if (istat /= 0) then
        write *, "GEOMNM1 is unspecified"
        CALL EXIT(1)
      end if

      CALL PXFGETENV('GEOMNM2', lenGEOMNM2, geomname2, lengeomname2,
     2          istat)
      if (istat /= 0) then
        write *, "No second GEOMNM is specified"
      end if

      CALL PXFGETENV('TAUI', lenTAUI, taui_val, lentaui_val, istat)
      if (istat /= 0) then
        write *, "TAUI is unspecified"
        CALL EXIT(1)
      endif

      CALL PXFGETENV('TAUE', lenTAUE, taue_val, lentaue_val, istat)
      if (istat /= 0) then
        write *, "TAUE is unspecified"
        CALL EXIT(1)
      endif

      CALL PXFGETENV('TAUINC', lenTAUINC, tauinc_val, lentauinc_val,
  2          istat)
   if (istat /= 0) then
     write *, "TAUINC is unspecified"
     CALL EXIT(1)
   endif

   CALL PXFGETENV('CRDATE', lenCRDATE, crdate_val, lencrdate_val,
  2          istat)
   if (istat /= 0) then
     write *, "CRDATE is unspecified"
     CALL EXIT(1)
   endif

   CALL PXFGETENV('NAMLIST_FILE1', lenNAMLIST_FILE1,
  2          namlist_file1_val, lennamlist1_val, istat)
   if (istat /= 0) then
     write *, "NAMLIST_FILE1 is unspecified"
   endif

   CALL PXFGETENV('NAMLIST_FILE2', lenNAMLIST_FILE2,
  2          namlist_file2_val, lennamlist2_val, status)
   if (status /= 0) then
     write *, "no second namlist file."
   endif

   if (istat /= 0 .and. status /= 0) then
     write *, "cannot continue without the namlist files."
     CALL EXIT(1)
   endif

c************************************************************************
c    get ISIS info on the given geometry by calling GGRD
c    geom is defined as a SMS env var
c    will add the capability to add the geom info in the future
c    when the geom info is not defined in ISIS
c************************************************************************
   CALL GGRD(geomname, ngeom, istat)
   !if geom is not defined then exit the program
   if (istat .ne. 0) then
     write (0,'("undefined geom, ggrd returns istat =",i5)') istat
     CALL EXIT(5)
   end if

   print *, 'taui=', taui_val, ' taue=', taue_val,
  2       ' tauinc=', tauinc_val
   print *, 'model=', modelname
   print *, 'geomnm=', geomname

c************************************************************************
c    need to convert tau info to integers
c************************************************************************
   CALL CH2INT(taui_val, itaui, istat)
```

```
      if (istat .ne. 0) then
        write (0,'("ch2int on TAUI returns istat =",i5)') istat
        CALL EXIT(2)
      end if

      CALL CH2INT(taue_val, itaue, istat)
      if (istat .ne. 0) then
        write (0,'("ch2int on TAUE returns istat =",i5)') istat
        CALL EXIT(2)
      end if

      CALL CH2INT(tauinc_val, itauinc, istat)
      if (istat .ne. 0) then
        write (0,'("ch2int on TAUINC returns istat =",i5)') istat
        CALL EXIT(2)
      end if

c************************************************************************
c     Initialize the arrays
c************************************************************************
      do m=1, maxprm
        parm(m) = cnul
        dsetname(m) = cnul
        odsetname(m) = cnul
        units(m) = cnul
        lvltype(m) = cnul
        sfc_parm(m) = cnul
        sfc_dsetname(m) = cnul
        sfc_odsetname(m) = cnul
        sfc_units(m) = cnul
        sfc_lvltype(m) = cnul
        obstype(m) = cnul
        sfc_obstype(m) = cnul
      end do

      do m=1, maxlvl
        level(m) = paknul
        sfc_level(m) = paknul
      end do

      do n=1, maxstat
        stats(n) = cnul
        sfc_stats(n) = cnul
      end do

c************************************************************************
    !Open and read the NAMLIST_FILE1 into the arrays for parm,
    !unit, lvl_type, level_1, and obs_type

    !determine the number of parameters and number of levels
    !number of stats and number of obstype
    !determine the array size
```

```
c***********************************************************************
      if (namlist_file1_val /= cnul) then
        open (unit=lstat,file=namlist_file1_val,form='formatted',
     2       status='old' ,iostat=istat)
        if (istat .eq. 0) read(lstat, nml = verlst)

c***********************************************************************
c     Finish setup, the arrays, stype, tval, typlvl, units are changed
c     to 1-dimension and will not change throughout the program so that
c     they can be used for multiple parameters which is a change from
c     the original program.
c***********************************************************************
c     Determine the number of parameters
c***********************************************************************
        nparm = 0
        do while (parm(nparm+1) .ne. cnul .and. nparm .lt. maxprm)
          nparm = nparm + 1
        end do

        if (nparm .eq. 0) then
          write (0,'("No verification parameters specified")')
c           CALL EXIT(3)
        end if

c***********************************************************************
c     Determine the number of levels
c***********************************************************************
        nlevel = 0
        do while (level(nlevel+1) .ne. paknul .and. nlevel .lt. maxlvl)
          nlevel = nlevel + 1
        end do

        if (nlevel .eq. 0) then
          write (0,'("No verification levels specified.")')
c           CALL EXIT(3)
        end if

c***********************************************************************
c     Determine the number of stats
c***********************************************************************
        nstat = 0
        do while (stats(nstat+1) .ne. cnul .and.
     2          nstat .lt. maxstat)
          nstat = nstat + 1
        end do

        if (nstat .eq. 0) then
          write (0,'("No statistics are requested.")')
c           CALL EXIT(3)
        end if

      end if !namlist_file1 exists
```

```
c************************************************************************
c     if NAMLIST_FILE2 exists, read it and put into the arrays for
c     the surface
c************************************************************************
      if (namlist_file2_val /= cnul) then
        open (unit=lstat, file=namlist_file2_val,
     2        form='formatted', status='old', iostat=istat)

        if (istat .eq. 0) then
          read(lstat, nml = sfclst)
          sfc_nparm = 0
          do while (sfc_parm(sfc_nparm+1) .ne. cnul .and.
     2              sfc_nparm .lt. maxprm)
            sfc_nparm = sfc_nparm + 1
          end do
          sfc_nstat = 0
          do while (sfc_stats(sfc_nstat+1) .ne. cnul .and.
     2              sfc_nstat .lt. maxstat)
            sfc_nstat = sfc_nstat + 1
          end do
          if (sfc_nstat .eq. 0) then
            write (0,'("No statistics are requested in sfc.")')
c             CALL EXIT(3)
          end if
        end if !if namlist_file2 was read successfully
      end if !if namlist_file2 exists

c************************************************************************
c     array size based on the namlists
c************************************************************************
      arr_size = nparm*nlevel
      sfc_arr_size = sfc_nparm

c************************************************************************
      !Fill the arrays of records from the parm, unit, lvl_type,
      !level_1 and obs_type arrays
c************************************************************************
      l = 1
      if (arr_size .gt. 0) then
        do i = 1, nparm
          do j = 1, nlevel
            verif(l)%param = parm(i)
            verif(l)%dsetnm = dsetname(i)
            verif(l)%obs_param = obs_parm(i)
            verif(l)%odsetnm = odsetname(i)
            verif(l)%unit = units(i)
            verif(l)%typlvl = lvltype(i)
            verif(l)%lvl_1 = level(j)
            verif(l)%obs_type = obstype(i)
            l = l + 1
          end do
        end do
      end if

c***********************************************************************
      !add the sfc stuff to the verif array
c***********************************************************************
      if (sfc_arr_size .gt. 0) then
        arr_size = arr_size + sfc_arr_size
        do i = 1, sfc_nparm
          verif(l)%param = sfc_parm(i)
          verif(l)%dsetnm = sfc_dsetname(i)
          verif(l)%obs_param = sfc_obs_parm(i)
          verif(l)%odsetnm = sfc_odsetname(i)
          verif(l)%unit = sfc_units(i)
          verif(l)%typlvl = sfc_lvltype(i)
          verif(l)%lvl_1 = sfc_level(i)
          verif(l)%obs_type = sfc_obstype(i)
          l = l + 1
        end do
      end if

c***********************************************************************
      !get geom info
c***********************************************************************
      CALL GETGEOM(ngeom,   prjnnm,  stdesc, ncols, nrows,
     2           origlat, origlon, origx,  origy, xintdis,
     3           yintdis, parm1,   parm2,  parm3, istat)

      if (istat .ne. 0) then
        write (0,'("getgeom returns istat =",i5)') istat
        CALL EXIT(6)
      end if

c***********************************************************************
c     Determine min/max lat/lon to use in obs read
c***********************************************************************
      CALL BOUNDARY(ngeom,  nrows,  ncols,  minlat,
     2             maxlat, minlon, maxlon, istat)

      if (istat .ne. 0) then
        write (0, '("cannot find min/max lat/lon")')
        CALL DBSTOP
        CALL EXIT(7)
      end if

c***********************************************************************
c     The output file, use modelname, geomname and crdate_val
c***********************************************************************
      l = strlen(modelname)
      outstats(1:l) = modelname(1:l)
      if (geomname2 == cnul) then
        numchar = strlen(geomname)
        k = l + numchar
        outstats(l+1:k) = geomname(1:numchar)
      else
        numchar = strlen(geomname2)
        k = l + numchar
        outstats(l+1:k) = geomname2(1:numchar)
      end if

      outstats(k+1:k+10) = crdate_val
      write (0,'("output file name = ", a50)')
     2     outstats(1:strlen(outstats))

      open(unit=lstat,file=outstats(1:strlen(outstats)),
     2   form='formatted',status='new',iostat=istat)

      if (istat .ne. 0) then
        write (0,'("istat = ", i5)') istat
        write (0,'("Cannot open output file for stats")')
        CALL EXIT(4)
      end if

c************************************************************************
c    Write the header in the output file
c************************************************************************
      write (lstat, '("   vdtg    "," numobs  ",
     2             "   param    "," unit  ",
     3             "    geometry     ",
     4             "   level type    ","     level 1",
     5             " tau "," stat type  ","   stat val  ",
     6             " v_src ","  obs_type ")')

c************************************************************************
c    for each parameter and level, read obs from LLT DB
c************************************************************************
      dtg(1:10) = crdate_val(1:10)

      do i=1, arr_size
        write (0,'("parm = ",a32)') verif(i)%param
        write (0,'("unit = ",a10)') verif(i)%unit
        write (0,'("type lvl = ",a10)') verif(i)%typlvl
        write (0,'("lvl 1 = ",f8.1)') verif(i)%lvl_1
        write (0,'("obs type = ",a15)') verif(i)%obs_type

        CALL LLTREAD(verif(i)%obs_type, verif(i)%obs_param,
     2             verif(i)%lvl_1,    verif(i)%odsetnm,
     3             dtg,            minlat,
     4             maxlat,            minlon,
     5             maxlon,            verif(i)%typlvl,
     6             oblat,            oblon,
     7             nobs,             obval,
     8             istat)

        write (0,'("nobs = ",i6)') nobs
      if (istat /= 0 .or. nobs == 0) then
        go to 100
      end if

c***********************************************************************
c     for each tau read the fcst, interpolate the fcst to obs
c     compute the stats and output the stats.
c***********************************************************************
      do ltau = itaui, itaue, itauinc

        !determine the correct dtg table to read
        CALL DTGMOD(dtg, -ltau, cdtg, istat)
        if (istat /= 0) then
          go to 200
        end if

c***********************************************************************
c       ISIS has tables for 00 and 12 only, therefore if we need
c       to read other tau model forecasts, e.g., 3, 6, 9, 15, 18, 21
c       etc., we need to read 12 hour old table
c       if cdtg ends with anything other than 00 or 12 then
c       use -12 ISIS table dtg
c***********************************************************************
        if (cdtg(9:10) /= '00' .and. cdtg(9:10) /= '12') then
          CALL DTGMOD(tdtg, -12, cdtg, istat)
          if (istat /= 0) then
            write *, 'DTGMOD error for tau ', ltau
            go to 200
          end if
        else
          tdtg = cdtg
        end if
        write (0,'("ISIS table dtg =",a10)') cdtg
        write (0,'("tau =",i5)') ltau
        ftau = ltau

c***********************************************************************
c       if everything is OK, then read the forecast
c       (gridded data) by calling ISIS GRD
c       ISIS grid does not have wnd_spd, therefore have to
c       read wnd_ucmp, wnd_vcmp then compute wnd_spd
c***********************************************************************
        if (verif(i)%param == 'wnd_spd') then

c======================================================================
c          read forecast for wnd_ucmp:  ISIS grid data
c======================================================================
          CALL GRD(modelname,      geomname,
     2              verif(i)%dsetnm, 'wnd_ucmp',
     3              verif(i)%typlvl, verif(i)%lvl_1,
     4              level_2,        cdtg,
     5              ftau,           verif(i)%unit,
     6          fcstu,        title,
     7          seclvl,       id,
     8          iseq,         status)
        if (status /= 0) then
          go to 200
        end if

c=======================================================================
c       read forecast for wnd_vcmp:  ISIS grid data
c=======================================================================
        CALL GRD(modelname,      geomname,
     2          verif(i)%dsetnm, 'wnd_vcmp',
     3          verif(i)%typlvl, verif(i)%lvl_1,
     4          level_2,       cdtg,
     5          ftau,          verif(i)%unit,
     6          fcstv,         title,
     7          seclvl,        id,
     8          iseq,          status)
        if (status /= 0) then
          go to 200
        end if

c=======================================================================
c       first interpolate into another geometry if the second
c       geometry is requested
c=======================================================================
        if (geomname2 /= cnul .and. geomname2 /= geomname) then
          CALL INTGEOM(geomname, geomname2, ijmax, fcstu,
     2        fcstu2, istat)
          if (istat == 0) fcstu = fcstu2
          CALL INTGEOM(geomname, geomname2, ijmax, fcstv,
     2        fcstv2, istat)
          if (istat == 0) fcstv = fcstv2
          CALL GGRD(geomname2, ngeom, istat)
        end if

c=======================================================================
c       interpolate forecast into obs points, then
c       convert wnd_ucmp and wnd_vcmp to wnd_spd by calling
c       uv2df
c=======================================================================
        CALL F2OB(ngeom, fcstu, oblat, oblon, nobs, fu, istat)
        CALL F2OB(ngeom, fcstv, oblat, oblon, nobs, fv, istat)

c***********************************************************************
c       if fcst had any missing value, f2ob fills fob with
c       -999 which needs to be disregarded in the conversion
c***********************************************************************
        k = 0
        do j=1, nobs
          if (fu(j) /= -999 .and. fv(j) /= 999) then
            k = k + 1
            newfu(k) = fu(j)
            newfv(k) = fv(j)
          end if
        end do
        CALL UV2DF(newfu, newfv, nobs, fdir, fob)

c***********************************************************************
c       If the parameter is other than winds,
c       call GRD only once
c***********************************************************************
       else

c======================================================================
c         read forecast: ISIS grid data
c======================================================================
        CALL GRD(modelname,      geomname,
   2          verif(i)%dsetnm, verif(i)%param,
   3          verif(i)%typlvl, verif(i)%lvl_1,
   4          level_2,       cdtg,
   5          ftau,          verif(i)%unit,
   6          fcst,          title,
   7          seclvl,         id,
   8          iseq,           status)

        if (status /= 0) then
          go to 200
        end if

c======================================================================
c         first interpolate into another geometry if the second
c         geometry is requested
c======================================================================
        if (geomname2 /= cnul .and. geomname2 /= geomname) then
          CALL INTGEOM(geomname, geomname2, ijmax, fcst,
   2         fcst2, istat)
          if (istat == 0) fcst = fcst2
          CALL GGRD(geomname2, ngeom, istat)
        end if

c***********************************************************************
        !interpolate fcst into obs pts
c***********************************************************************
        CALL F2OB(ngeom, fcst, oblat, oblon, nobs, fob, istat)
        if (istat /= 0) then
          go to 200
        end if

       end if !param test

c***********************************************************************
c       if fcst had any missing value, f2ob fills fob with
c       -999 which needs to be disregarded in the stat computations
```

```
c***********************************************************************
      k = 0
      do j=1, nobs
        if (fob(j) /= -999) then
          k = k + 1
          newfob(k) = fob(j)
          newlat(k) = oblat(j)
          newlon(k) = oblon(j)
          newobs(k) = obval(j)
        end if
      end do
      write (0,'("writing the 1st 15 lat,lon,obs,fcst.")')
      write (0,'(i5,4f10.2)') (n,newlat(n),newlon(n),newobs(n)
     2     ,newfob(n), n=1,15)

c***********************************************************************
      !compute the stats
      !for obs, disregard the projection
c***********************************************************************

      nul_geom = 'NONE'

c***********************************************************************
c      if there was no NAMLIST_FILE1, then use the stats
c      from NAMLIST_FILE2.  For ocean models
c***********************************************************************
      if (nstat == 0) then
        nstat = sfc_nstat
        do j = 1, nstat
          stats(j) = sfc_stats(j)
        end do
      end if

      if (geomname2 /= cnul) then
        outgeomname = geomname2
      else
        outgeomname = geomname
      end if

      do j = 1, nstat
        if (stats(j) == 'bias' .and. k /= 0) then
          CALL COMPUTE_BIAS(newfob,newobs,k,nul_geom,bias)
          !write the stats to the output file
          write (lstat, 1000) dtg, k, verif(i)%param,
     2                 verif(i)%unit,
     3                 outgeomname, verif(i)%typlvl,
     4                 verif(i)%lvl_1, ltau,
     5                 stats(j), bias,
     6                 verif(i)%obs_type
          write (0,'(a30, 2a15,f10.2)') verif(i)%obs_type,
     2            verif(i)%param, stats(j), bias
```

```
        else if (stats(j) == 'std' .and. k /= 0) then
          CALL COMPUTE_STD(newfob, newobs, k, nul_geom, std)
          write (lstat, 1000) dtg, k, verif(i)%param,
     2                   verif(i)%unit,
     3                   outgeomname, verif(i)%typlvl,
     4                   verif(i)%lvl_1, ltau,
     5                   stats(j), std,
     6                   verif(i)%obs_type
          write (0,'(a30, 2a15,f10.2)') verif(i)%obs_type,
     2             verif(i)%param, stats(j), std

        else if (stats(j) == 'rms' .and. k /= 0) then
          CALL COMPUTE_RMS(newfob, newobs, k, nul_geom, rms)
          write (lstat, 1000) dtg, k, verif(i)%param,
     2                   verif(i)%unit,
     3                   outgeomname, verif(i)%typlvl,
     4                   verif(i)%lvl_1, ltau,
     5                   stats(j), rms,
     6                   verif(i)%obs_type
          write (0,'(a30, 2a15,f10.2)') verif(i)%obs_type,
     2             verif(i)%param, stats(j), rms

c       else if (stats(j) == 'ancor' .and. k /= 0) then
c         CALL COMPUTE_RMS(newfob,newobs,k,nul_geom,ancor)
c         write (lstat, 1000) dtg, k, verif(i)%param,
c    2                   verif(i)%unit,
c    3                   outgeomname, verif(i)%typlvl,
c    4                   verif(i)%lvl_1, ltau,
c    5                   stats(j), ancor,
c    6                   verif(i)%obs_type
c         write (0,'(a30, 2a15,f10.2)') verif(i)%obs_type,
c    2             verif(i)%param, stats(j), ancor

        !other stat types ...
        end if
       end do !do j=1,nstat
 200    continue
      end do !ltau loop
 100  continue
    end do ! i=1,arr_size loop

1000 format (a10,i6,1x,2a15,a30,a15,f8.2,i5,1x,a12,f8.2,' obs',1x,a15)
    close(lstat)
    CALL DBSTOP
    stop 'Normal End'
    CALL EXIT(0)
    end
```

5. boundary.f90

```
    subroutine boundary(ngeom,  nrows,  ncols,  minlat,
 2           maxlat, minlon, maxlon, istat)
C
C............................START PROLOGUE............................
C
C SCCS IDENTIFICATION: @(#)boundary.f90 1.1 04/24/98 /h/cm/library/mverif/src/sub/boundary.f90_v
C
C  CONFIGURATION IDENTIFICATION:  NONE
C
C  MODULE NAME:  boundary
C
C  DESCRIPTION: This subroutine computes the minimum and maximum
C          latitude and longitude for reading observations
C          from ISIS LLT database.
C
C  COPYRIGHT:             (c) 1996 FLENUMMETOCCEN
C                     U.S. GOVERNMENT DOMAIN
C                     ALL RIGHTS RESERVED
C
C  CONTRACT NUMBER AND TITLE:  N/A
C
C  REFERENCES: NONE
C
C  CLASSIFICATION:  Unclassified
C
C  RESTRICTIONS:  NONE
C
C  COMPUTER/OPERATING SYSTEM
C          DEPENDENCIES:  Cray UNICOS
C
C  LIBRARIES OF RESIDENCE: /a/ops/bin
C
C  USAGE:
C   call boundary(igeom,  nrows,  ncols,  minlat,
C            maxlat, minlon, maxlon, istat)
C
C  PARAMETERS:
C    Name        Type      Usage        Description
C   ----------    ----------   ------- ----------------------------
C   NGEOM       INTEGER      INPUT   Geometry info.
C   NROWS       INTEGER      INPUT   No. of rows
C   NCOLS      INTEGER      INPUT   No. of columns
C   MINLAT      REAL       OUTPUT  Minimum latitude
C   MAXLAT       REAL       OUTPUT  Maximum latitude
C   MINLON      REAL       OUTPUT  Minimum longitude
C   MAXLON       REAL       OUTPUT  Maximum longitude
C   ISTAT      INTEGER      OUTPUT  Return status
C
C  COMMON BLOCKS: N/A
C
C  FILES: N/A
C
C  DATA BASES: N/A
```

```
C
C NON-FILE INPUT/OUTPUT: N/A
C
C ERROR CONDITIONS:
C     CONDITION            ACTION
C   -----------------     ----------------------------
C  Error return from VXYLL   Print err message
C
C ADDITIONAL COMMENTS:  NONE
C
C...................MAINTENANCE SECTION...............................
C
C MODULES CALLED:
C       Name        Description
C       -------     ----------------------
C      MAXVAL    Returns maximum value from an array
C      MINVAL    Returns minimum value from an array
C      VXYLL     Computes arrays of lat/lon from arrays of x/y
C
C LOCAL VARIABLES AND       Structures are documented in detail
C        STRUCTURES:       where they are defined in the code
C                      within include files.
C
C METHOD: 1. Fill in the working arrays, x & y, with values for left,
C           right, bottom & top boundaries.
C        2. Call vxyll to get lat/lon from x & y.
C        3. Find the minimum & maximum latitude & longitude.
C
C INCLUDE FILES: NONE
C
C COMPILER DEPENDENCIES: f90
C
C COMPILE OPTIONS:  -f fixed -c
C
C MAKEFILE: Located at /a/ops/app/mverif/src/sub/makeverobslib
C         UNICOS make
C
C RECORD OF CHANGES:
C
C <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
C    Initial submission
C    Originial Programmer: M.A. Rennick
C
C.............................END PROLOGUE............................
C
      implicit none

!*****************************************************************
!   parameters
!*****************************************************************
      integer, intent(in)  :: ngeom  ! geometry
      integer, intent(in)  :: nrows  ! no of rows
```

```
   integer, intent(in)  :: ncols  ! no of columns
   real,    intent(out) :: minlat ! min lat
   real,    intent(out) :: maxlat ! max lat
   real,    intent(out) :: minlon ! min lon
   real,    intent(out) :: maxlon ! max lon
   integer, intent(out) :: istat  ! return status

!******************************************************************
!   local variables
!******************************************************************
   integer :: len                 ! array size
   integer :: i                   ! dummy loop var
   integer :: n                   ! temp var to hold array value
   real    :: x(2*nrows + 2*ncols)   ! working array 1st dimension
   real    :: y(2*nrows + 2*ncols)   ! working array 2nd dimension
   real    :: lat(2*nrows + 2*ncols) ! latitude array
   real    :: lon(2*nrows + 2*ncols) ! longitude array

!******************************************************************
!   for left boundary
!******************************************************************
   do i=1, nrows
     x(i) = 1 ! all x value at the left boundary is 1
     y(i) = i ! y value at the left boundary
   end do

!******************************************************************
!   for right boundary
!******************************************************************
   n = 0  ! initialize the temp var
   do i=nrows+1, 2*nrows
     x(i) = ncols ! all x value at the right boundary
     n = n + 1
     y(i) = n     ! y value at the right boundary
   end do

!******************************************************************
!   for bottom boundary
!******************************************************************
   n = 0  ! initialize the temp var
   do i=2*nrows+1, 2*nrows+ncols
     n = n + 1
     x(i) = n     ! all x value at the bottom boundary
     y(i) = 1     ! y value at the bottom boundary
   end do

!******************************************************************
!   for top boundary
!******************************************************************
   n = 0  ! initialize the temp var
   do i=2*nrows+ncols+1, 2*nrows+2*ncols
     n = n + 1
```

```
      x(i) = n     ! all x value at the bottom boundary
      y(i) = nrows ! y value at the bottom boundary
    end do

!****************************************************************
!   call vxyll to get the lat/lon from x/y
!****************************************************************
    len = 2*nrows + 2*ncols
    call vxyll(ngeom, len, x, y, 'd', lat, lon, istat)

    if (istat .eq. 0) then

!****************************************************************
!   get the min/max lat/lon
!****************************************************************
       minlat = minval(lat)
       maxlat = maxval(lat)
       minlon = minval(lon)
       maxlon = maxval(lon)

     else
       write (*,'("vxyll returns istat =",i5)') istat
     end if

    return
    end subroutine boundary
```

6. f2ob.f90

```
    subroutine f2ob(igeom,field,obslat,obslon,nobs,fob,istat)
C
C.............................START PROLOGUE............................
C
C  SCCS IDENTIFICATION:  @(#)f2ob.f90 1.1 04/24/98 /h/cm/library/mverif/src/sub/f2ob.f90_v
C
C  CONFIGURATION IDENTIFICATION:   NONE
C
C  MODULE NAME:  f2ob
C
C  DESCRIPTION: This subroutine interpolates forecast field values to
C             observation locations.
C
C  COPYRIGHT:               (c) 1998 FLENUMMETOCCEN
C                        U.S. GOVERNMENT DOMAIN
C                        ALL RIGHTS RESERVED
C
C  CONTRACT NUMBER AND TITLE:   N/A
C
C  REFERENCES: NONE
C
C  CLASSIFICATION:   Unclassified
```

```
C
C RESTRICTIONS:  NONE
C
C COMPUTER/OPERATING SYSTEM
C          DEPENDENCIES:  Cray UNICOS
C
C LIBRARIES OF RESIDENCE:  /a/ops/bin
C
C USAGE:
C   call f2ob(igeom,field,obslat,obslon,nobs,fob,istat)
C
C PARAMETERS:
C    Name         Type       Usage        Description
C  ----------   ----------   ------- ----------------------------
C  IGEOM        INTEGER      INPUT    Geometry info.
C  FIELD        REAL         INPUT    Forecast array to interpolate
C  OBSLAT       REAL         INPUT    Obs. latitude
C  OBSLON       REAL         INPUT    Obs. longitude
C  NOBS         INTEGER      INPUT    No. of observations
C  FOB          REAL         OUTPUT   Fcst interpolated to obs array
C  ISTAT        INTEGER      OUTPUT   Return status
C
C COMMON BLOCKS: N/A
C
C FILES: N/A
C
C DATA BASES: N/A
C
C NON-FILE INPUT/OUTPUT: N/A
C
C ERROR CONDITIONS:
C      CONDITION              ACTION
C   -----------------      ----------------------------
C  Unsuccessful getgeom      Print err message and exit
C
C ADDITIONAL COMMENTS:  NONE
C
C....................MAINTENANCE SECTION................................
C
C MODULES CALLED:
C       Name        Description
C      -------    ----------------------
C      EXIT       System call that exits program
C      FINTRP     FORTRAN sub. that interpolates within a field to
C                 obtain values at an array of points
C      GETGEOM    Gets geometry arguments to be used by other routines
C      IMAXCV     FORTRAN function to determine max. 1st dimension
C                 of array
C      JMAXCV     FORTRAN function to determine max. 2nd dimension
C                 of array
C      VLLXY      Computes arrays of x/y from arrays of lat/lon
C
```

```
C LOCAL VARIABLES AND      Structures are documented in detail
C      STRUCTURES:      where they are defined in the code
C                    within include files.
C
C METHOD: 1. Call getgeom.
C      2. If successful getgeom, determine max. 1st & 2nd dimensions
C         of the array using imaxcv/jmaxcv.
C      3. Call vllxy to convert from lat/lon to i,j.
C      4. Call fintrp to interpolate.
C
C INCLUDE FILES:
C     Name                 Description
C   ---------------   ------------------------------------------------
C    V_DATA.H        contains the common variables for verobs
C
C COMPILER DEPENDENCIES:  f90
C
C COMPILE OPTIONS:   -f fixed -c
C
C MAKEFILE:  Located at /a/ops/app/mverif/src/sub/makeverobslib
C            UNICOS make
C
C RECORD OF CHANGES:
C
C <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
C     Initial submission
C     Original Programmer: MA Rennick
C
C.............................END PROLOGUE.............................
C
       implicit none
       include 'v_data.h'

!***************************************************************************
!   Formal parameters
!***************************************************************************
       integer, intent(in) :: igeom          ! geom ptr from ggrd
       integer, intent(in) :: nobs           ! number of obs to interpolate
       real,    intent(in) :: field(ijmax)   ! array to interpolate
       real,    intent(in) :: obslat(maxobs) ! lat of report
       real,    intent(in) :: obslon(maxobs) ! lon of report
       real,    intent(out) :: fob(maxobs)   ! interpolated array
       integer, intent(out) :: istat         ! status

!***************************************************************************
!   Local variables
!***************************************************************************
       integer      :: imx, jmx
       character(8) :: dsc
       real         :: dcol
       real         :: drow
       real         :: fx(maxobs)
```

```
      real          :: fy(maxobs)
      real          :: origi
      real          :: origj
      real          :: parm1, parm2, parm3

      double precision  :: olat
      double precision  :: olon

!***************************************************************************
!    Functions
!***************************************************************************
      integer imaxcv, jmaxcv

      CALL GETGEOM(igeom, prjnnm, dsc,  ncols, nrows, olat,  olon,
     2      origi, origj,  dcol, drow,  parm1, parm2, parm3, istat)

      if (ncols*nrows .gt. ijmax) istat = 2

!***************************************************************************
!    if successful getgeom, obtain max 1st and 2nd dimension of the array
!    and convert from lat/lon to i,j and interpolate
!***************************************************************************
      if (istat .eq. 0) then

        imx = imaxcv(ncols, nrows, dsc)
        jmx = jmaxcv(ncols, nrows, dsc)
        CALL VLLXY(igeom,nobs,obslat,obslon,'d',fx,fy,istat)
        if (istat .eq. 0) then
!            CALL FINTRP(fx,fy,nobs,field,imx,imx,jmx,0,0.,0.,0.,fob)
          CALL FINTRP(fx,fy,nobs,field,imx,imx,jmx,1,
     2              bad_value, -999., -999., fob)
        else
          write (*,'("vllxy returns istat =",i5)') istat
        end if

!***************************************************************************
!    if unsuccessful getgeom, print the error msg
!***************************************************************************
      else

        write (*,'("getgeom returns:"
     2         /"  prjnam = ",a
     3         /"  dsc    = ",a
     4         /"  ncols  = ",i5
     5         /"  nrows  = ",i5
     6         /"  olat   = ",f8.2
     7         /"  olon   = ",f8.2
     8         /"  origi  = ",f8.2
     9         /"  origj  = ",f8.2
     a         /"  dcol   = ",f8.2
     b         /"  drow   = ",f8.2
     c         /"  parm1  = ",f8.2
```

```
 d       /"  parm2  = ",f8.2
 e       /"  parm3  = ",f8.2
 f       /"  istat  = ",i5)') prjnnm,dsc,ncols,nrows,olat
 g        ,olon,origi,origj,dcol,drow,parm1,parm2,parm3,istat

    if (istat .eq. 2) then
      write (*,'("ERROR: Current geometry requires array "
 2       "length ge",i10,"; ijmax =",i10)') ncols*nrows,ijmax
      CALL EXIT (1)
    end if

  end if   ! (if istat == 0)

  return
  end subroutine f2ob
```

7. intgeom.f90

```
  subroutine intgeom(geomname1, geomname2, arr_size,
 2              field1,    field2,    istat)
C
C.............................START PROLOGUE............................
C
C SCCS IDENTIFICATION: @(#)intgeom.f90 1.1 04/24/98 /h/cm/library/mverif/src/sub/intgeom.f90_v
C
C  CONFIGURATION IDENTIFICATION:   NONE
C
C  MODULE NAME:  intgeom
C
C  DESCRIPTION:  Interpolates one geometry to another geometry for
C             spherical projection.
C
C  COPYRIGHT:                (c) 1998 FLENUMMETOCCEN
C                        U.S. GOVERNMENT DOMAIN
C                        ALL RIGHTS RESERVED
C
C  CONTRACT NUMBER AND TITLE:   N/A
C
C  REFERENCES: NONE
C
C  CLASSIFICATION:   Unclassified
C
C  RESTRICTIONS:   NONE
C
C  COMPUTER/OPERATING SYSTEM
C            DEPENDENCIES:  Cray UNICOS
C
C  LIBRARIES OF RESIDENCE:   /a/ops/bin
C
C  USAGE:
C    call intgeom(geomname1, geomname2,arr_size, field1, field2, istat)
```

```
C
C PARAMETERS:
C   Name        Type      Usage       Description
C  ----------   ----------   ------- ----------------------------
C  GEOMNAME1     CHAR*32      INPUT   GEOMETRY TO INTERPOLATE FROM
C  GEOMNAME2     CHAR*32      INPUT   GEOMETRY TO INTERPOLATE TO
C  ARR_SIZE     INTEGER     INPUT   ARRAY_SIZE
C  FIELD1       REAL(ijmax)  INPUT   ARRAY TO INTERPOLATE FROM
C  FIELD2       REAL(ijmax)  OUTPUT  INTERPOLATED ARRAY
C  ISTAT       INTEGER      OUTPUT  STATUS
C
C COMMON BLOCKS: N/A
C
C FILES: NONE
C
C DATA BASES: $META_GRID_DB
C    Name        Table     Usage       Description
C  ----------    --------------  ---------   -------------------------
C
C NON-FILE INPUT/OUTPUT: NONE
C
C ERROR CONDITIONS:
C     CONDITION            ACTION
C   -----------------     ----------------------------
C Error return from GGRD      Print err message & exit
C Error return from GETGEOM   Print err message & exit
C Error return from VXYLL     Print err message & exit
C Error return from CHGEOM    Print err message & exit
C
C ADDITIONAL COMMENTS:  NONE
C
C....................MAINTENANCE SECTION................................
C
C MODULES CALLED:
C      Name      Description
C      -------   ----------------------
C      CHGEOM    CHANGES THE GEOMETRY
C      EXIT      System call that exits program
C      GETGEOM   Gets geometry arguments to be used by other routines
C      GGRD      Returns ISIS info. on given geometry
C      IMAXCV    Selects the first dimension of a field
C      JMAXCV    Selects the second dimension of a field
C      VXYLL     Converts i/j to lat/lon
C
C LOCAL VARIABLES AND
C       STRUCTURES:
C
C      Name    Type            Description
C      ------  ----    ----------------------------------------
C      CNCOLS   INTEGER   column count (getgeom, geomname1)
C      CNROWS    INTEGER   row count (getgeom, geomname1)
C      CORIGLAT  DOUBLE    latitude of origin (getgeom,
C
C      CORIGLON  DOUBLE    longtitude of origin (getgeom, geomname1)
C      CORIGX    REAL      x coordinate of origin (getgeom,geomname1)
C      CORIGY    REAL      y coordinate of origin (getgeom,geomname1)
C      CPARM1    REAL      geometry parameter #1 (getgeom,geomname1)
C      CPARM2    REAL      geometry parameter #2 (getgeom,geomname1)
C      CPARM3    REAL      geometry parameter #3 (getgeom,geomname1)
C      CPRJNAM   CHAR*24   projection name (getgeom, geomname1)
C      CSTDESC   CHAR*24   storage description (getgeom,geomname1)
C      CXINTDIS  REAL      interval distance between columns (getgeom,geomname1)
C      CYINTDIS  REAL      interval distance between rows (getgeom,geomname1)
C      FILVAL    REAL      chgeom parameter
C      FLAT      REAL      latitude array
C      FLON      REAL      longtitude array
C      FVALI     REAL      chgeom parameter
C      FVALO     REAL      chgeom parameter
C      FW1       REAL      work array for chgeom
C      FW2       REAL      work array for chgeom
C      GEOMI     INTEGER   data structure containing the input
C                            grid definition (chgeom)
C      GGEOM     CHAR*32   data structure containing the output
C                            grid definition (chgeom)
C      GMODEL    CHAR*32   NOGAPS model
C      I         INTEGER   counter
C      IFLAGI    INTEGER   input field flag (chgeom)
C      IMAX      INTEGER   first dimension of an array
C      ISFLG     INTEGER   chgeom flag
C      ISTGR     INTEGER   stagger flag (chgeom)
C      IVEC      INTEGER   vector flag (chgeom)
C      IWRP      INTEGER   wrap flag (chgeom)
C      J         INTEGER   counter
C      JMAX      INTEGER   second dimension of an array
C      LAFLAG    INTEGER   land average flag (chgeom)
C      LAPASS    INTEGER   number of passes (chgeom)
C      LASRCH    INTEGER   number of points to search (chgeom)
C      LAVAL     REAL      values in the field (chgeom)
C      LEN       INTEGER   total number of element in an array
C      LSTATS    INTEGER   output unit
C      NCOLS     INTEGER   column count
C      NGEOM     INTEGER   data structure containing the input
C                            grid definition (chgeom)
C      NRFCST    REAL      NORAPS forecast field
C      NRFCSTU   REAL      NORAPS wind_u forecast
C      NRFCSTV   REAL      NORAPS wind_v forecast
C      NROWS     INTEGER   row count
C      ORIGLAT   DOUBLE    latitude of origin
C      ORIGLON   DOUBLE    longitude of origin
C      ORIGX     REAL      x coordinate of origin
C      ORIGY     REAL      y coordinate of origin
C      PARM1     REAL      geometry parameter #1
C      PARM2     REAL      geometry parameter #2
C      PARM3     REAL      geometry parameter #3
```

```
C      PRJNAM    CHAR*24   projection name
C      STDESC    CHAR*24   Storage description
C      XINTDIS   REAL      Interval distance between columns
C      YINTDIS   REAL      Interval distance between rows
C
C METHOD:
c    1. Get ISIS information on geomname1 by calling GGRD and
c      GETGEOM.
c    2. Call GGRD and GETGEOM on the geomname2.
c    3. Test for 'spherical' projection.
c    4. Find the first and second dimension of the geomname2.
c    5. Convert i/j to lat/lon by calling vxyll.
c    6. Interpolate field1 to field2 by calling CHGEOM.
C
C INCLUDE FILES: NONE
C
C COMPILER DEPENDENCIES:  f90
C
C COMPILE OPTIONS:   -f fixed -c
C
C MAKEFILE: Located at /a/ops/app/mverif/src/sub/makeverobslib
C        UNICOS make
C
C RECORD OF CHANGES:
C
C <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk
C    Initial submission
C
C.............................END PROLOGUE............................
C
      implicit none

c*********************************************************************
c   Formal parameters
c*********************************************************************
      character(32), Intent(in) :: geomname1     ! first geometry name
      character(32), Intent(in) :: geomname2     ! second geom name
      integer,       Intent(in) :: arr_size      ! array size
      real,          Intent(in) :: field1(arr_size)!array to interpolate
      real                      :: field2(arr_size)!interpolated array
      integer                   :: istat         ! status

c*********************************************************************
c   Local variables
c*********************************************************************
      character*1  uv
      character*24 stdesc, cstdesc
      character*24 prjnam, cprjnam
      character*32 gmodel, ggeom

      integer i, j
      integer lstats, ngeom
      integer geomi, ncols, nrows
      integer cncols, cnrows, im, jm, imax, jmax, len
      integer ivec, iwrp, istgr, iflagi, laflag, lasrch, lapass, isflg

      real    fvali, fvalo, filval, laval
      real    origx, origy, parm1, parm2, parm3, xintdis, yintdis
      real    corigx, corigy, cparm1, cparm2, cparm3, cxintdis, cyintdis

      parameter (im = 360)
      parameter (jm = 181)
      real    fw1(im,jm), fw2(im,jm), flat(im,jm), flon(im,jm)

      double precision origlat, origlon, coriglat, coriglon
      parameter (uv = 'd') ! for vxyll 'd' means in degrees

c***********************************************************************
c   Functions
c***********************************************************************
      integer imaxcv, jmaxcv

c***********************************************************************
c    get ISIS info on the geometry1 by calling GGRD
c    and GETGEOM
c***********************************************************************
      call GGRD(geomname1, geomi, istat)
      if (istat .ne. 0) then
        write (0,'("ggrd for geomname1 returns istat =",i5)') istat
        call exit(11)
      end if
      call getgeom(geomi, cprjnam, cstdesc, cncols, cnrows, coriglat,
     2     coriglon, corigx, corigy, cxintdis, cyintdis, cparm1,
     3     cparm2, cparm3, istat)

      if (istat .ne. 0) then
        write (0,'("getgeom for geomname returns istat =",i5)') istat
        call exit(11)
      end if

      if (cprjnam .ne. 'spherical') then
      write(0,'("projection name for geomname1 is not spherical")')
        call exit(11)
      end if

c***********************************************************************
c    get ISIS info on the geometry2 by calling GGRD
c***********************************************************************
      call ggrd(geomname2,ngeom,istat)
      if (istat .ne. 0) then
        write (0,'("ggrd for geomname2 returns istat =",i5)') istat
        call exit(11)
      end if
      call getgeom(ngeom, prjnam, stdesc, ncols, nrows, origlat,
     2      origlon, origx, origy, xintdis, yintdis, parm1, parm2,
     3      parm3, istat)

      if (istat .ne. 0) then
        write (0,'("getgeom for geomname2 returns istat =",i5)')
     2        istat
        call exit(11)
      end if

      if (prjnam .ne. 'spherical') then
      write(0,'("projection name for geomname2 is not spherical")')
        call exit(11)
      end if

c=====================================================================
c     convert the i,j to lat/lon
c     ref: /a/library/omsp/chgeom/src/sub/chgeom.f
c     flat=array of latitudes from vxyll for new 2-D array geomo
c     flon=array of longitudes from vxyll for new 2-D array geomo
c=====================================================================
      imax=imaxcv(ncols,nrows,stdesc)
      jmax=jmaxcv(ncols,nrows,stdesc)
      do j=1, jmax
        do i=1, imax
          fw1(i,j) = float(i)
          fw2(i,j) = float(j)
        enddo
      enddo

      len = imax*jmax
      call vxyll(ngeom, len, fw1, fw2, uv, flat, flon, istat)
      if (istat .ne. 0) then
        write(0,'("VXYLL error")')
        call exit(11)
      endif

c=====================================================================
c     set some of the chgeom parameter values (ref: chgeom write-up)
c=====================================================================
      ivec = 1
      iwrp = 1
      istgr = 0
      iflagi = 0
      fvali = 0.0
      fvalo = 0.0
      laflag = 0
      lasrch = 20
      laval = 0.0
      lapass = 0
      filval =0.0
      isflg = 0
```

```
c=========================================================================
c   change the field1 to field2
c=========================================================================
    call chgeom(field1, field1, cncols, cnrows, geomi, imax, jmax,
   1        ngeom, ivec, iwrp, istgr, iflagi, fvali, fvalo,
   2        laflag, lasrch, laval, lapass, filval, isflg,
   3        fw1, fw2, field2, field2, istat)
    if (istat .ne. 0) then
      write(0,'("CHGEOM error in intgeom")')
      call exit(11)
    endif

    return
    end subroutine intgeom
```

8. uv2df.f90

```
    subroutine uv2df(u, v, n, dir, spd)
C
C.............................START PROLOGUE............................
C
C  SCCS IDENTIFICATION:  @(#)uv2df.f90 1.1 04/24/98 /h/cm/library/mverif/src/sub/uv2df.f90_v
C
C  CONFIGURATION IDENTIFICATION:   NONE
C
C  MODULE NAME:  uv2df
C
C  DESCRIPTION: This subroutine converts u/v components to a
C           field of direction/speed (dd/ff).
C
C  COPYRIGHT:               (c) 1996 FLENUMMETOCCEN
C                       U.S. GOVERNMENT DOMAIN
C                       ALL RIGHTS RESERVED
C
C  CONTRACT NUMBER AND TITLE:   N/A
C
C  REFERENCES:  NONE
C
C  CLASSIFICATION:  Unclassified
C
C  RESTRICTIONS:  NONE
C
C  COMPUTER/OPERATING SYSTEM
C           DEPENDENCIES:  Cray UNICOS
C
C  LIBRARIES OF RESIDENCE:  /a/ops/bin
C
C  USAGE:
C    call uv2df(u, v, n, dir, spd)
C
C  PARAMETERS:
```

```
C    Name       Type      Usage       Description
C  ----------  ----------  -------  ---------------------------
C  U         REAL      INPUT    Wind u-comp fcst interpolated to obs
C  V         REAL      INPUT    Wind v-comp fcst interpolated to obs
C  N         INTEGER     INPUT   No. of observations
C  DIR        REAL      OUTPUT   Converted direction array
C  SPD        REAL      OUTPUT   Converted speed array
C
C COMMON BLOCKS: N/A
C
C FILES: N/A
C
C DATA BASES: N/A
C
C NON-FILE INPUT/OUTPUT: N/A
C
C ERROR CONDITIONS: N/A
C
C ADDITIONAL COMMENTS:  NONE
C
C...................MAINTENANCE SECTION...............................
C
C MODULES CALLED: N/A
C
C LOCAL VARIABLES AND       Structures are documented in detail
C       STRUCTURES:      where they are defined in the code
C                   within include files.
C       Name    Type           Description
C       ------   ----   ----------------------------------------
C       I       INTEGER   Counter
C       R2D      REAL      45.0 / atan(1.0)
C
C METHOD:
C   Convert u/v to dir/spd by using simple trigonometric functions.
C
C INCLUDE FILES: NONE
C
C COMPILER DEPENDENCIES:  f90
C
C COMPILE OPTIONS: -f fixed -c
C
C MAKEFILE:  Located at /a/ops/app/mverif/src/sub/makeverobslib
C         UNICOS make
C
C RECORD OF CHANGES:
C
C <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
C    Initial submission
C    Original Programmer: M.A. Rennick
C
C.............................END PROLOGUE............................
C
```

```
      implicit none

c*****************************************************************
c     formal parameters
c*****************************************************************
      real u(n), v(n), dir(n), spd(n)
      integer n

c*****************************************************************
c     local variables
c*****************************************************************
      integer i
      real r2d
      real badval
      parameter(badval=1.E+10)

      r2d = 45.0 / atan(1.0)

      do i = 1, n
        if (u(i) .eq. badval) then
          dir(i) = 999.0
          spd(i) = 999.0
        else
          if (u(i) .eq. 0.0) then
            u(i) = 1.0e-6
          end if
          dir(i) = 270.0 - r2d * atan2(v(i), u(i))
          if (dir(i) .gt. 360.0) then
            dir(i) = dir(i) - 360.0
          end if
          spd(i) = sqrt(u(i)*u(i) + v(i)*v(i))
        end if
      end do

      return
      end subroutine uv2df
```

9. lltread.f90

```
      subroutine lltread(seq_type, param,   lvl,    dsetnm,
     2                  dtg,     minlat,  maxlat, minlon,
     3                  maxlon,  typlvl,  obslat, obslon,
     4                  nobs,    obsval,  istat)
C
C.............................START PROLOGUE............................
C
C SCCS IDENTIFICATION: @(#)lltread.f90 1.1 04/24/98 /h/cm/library/mverif/src/sub/lltread.f90_v
C
C  CONFIGURATION IDENTIFICATION:   NONE
C
C  MODULE NAME:  lltread
```

```
C
C DESCRIPTION: This module calls the appropriate latitude-
C             longitude-time (llt) read module based upon
C             the user specificed llt sequence type(s).
C             There are separate read modules for each sequence
C             type because of the different include files and
C             data structure in the ISIS for the
C             different observation types.
C
C COPYRIGHT:          (c) 1996 FLENUMMETOCCEN
C                     U.S. GOVERNMENT DOMAIN
C                     ALL RIGHTS RESERVED
C
C CONTRACT NUMBER AND TITLE:  N/A
C
C REFERENCES: ISIS LLT User's Manual
C
C CLASSIFICATION:  Unclassified
C
C RESTRICTIONS:  NONE
C
C COMPUTER/OPERATING SYSTEM
C           DEPENDENCIES:  Cray UNICOS
C
C LIBRARIES OF RESIDENCE:  /a/ops/bin
C
C USAGE:
C  call lltread(seq_type, param, lvl, dsetnm, dtg,
C           minlat, maxlat, minlon, maxlon, typlvl,
C           obslat, obslon, nobs, obsval, istat)
C
C PARAMETERS:
C   Name        Type      Usage       Description
C  ----------  ----------  -------  ----------------------------
C  SEQ_TYPE     char*24     INPUT   LLT obs type
C  PARAM       CHAR*32      INPUT   Parameter to read eg. air_temp
C  LVL        REAL        INPUT   Pressure level
C  DSETNM        CHAR*24     INPUT   ISIS dataset name
C  DTG         CHAR*10     INPUT   Date Time Group for read
C  MINLAT       REAL        INPUT   Minimum latitude of the area
C  MAXLAT        REAL        INPUT   Maximum latitude of the area
C  MINLON       REAL        INPUT   Minimum longitude of the area
C  MAXLON        REAL        INPUT   Maximum longitude of the area
C  TYPLVL       CHAR*24      INPUT   level type
C  OBSLAT       REAL(maxobs)  OUTPUT  Observation latitude
C  OBSLON       REAL(maxobs)  OUTPUT  Observation longitude
C  NOBS        INTEGER      OUTPUT  No of good obs read
C  OBSVAL       REAL(maxobs)  OUTPUT  Observed parameter value
C  ISTAT       INTEGER      OUTPUT  Status
C
C COMMON BLOCKS: N/A
C
```

```
C FILES: NONE
C
C DATA BASES: NONE
C
C NON-FILE INPUT/OUTPUT: N/A
C
C ERROR CONDITIONS:
C      CONDITION              ACTION
C   -----------------      ----------------------------
C   Numobs exceeds maxobs    Print err message & return
C   (istat = -1)
C
C ADDITIONAL COMMENTS:   NONE
C
C....................MAINTENANCE SECTION................................
C
C MODULES CALLED:
C       Name             Description
C   ---------------    ----------------------
C   RAOB_QC_READ        reads ISIS raob_qc llt data
C   SFC_LAND_READ       reads ISIS surface land llt data
C   SFC_SHIP_READ       reads ISIS surface ship met llt data
C   SFC_SHIP_MET_QC_READ  reads ISIS sfc ship met qc llt data
C   ALTY_READ           reads ISIS alty llt data
C
C LOCAL VARIABLES AND        Structures are documented in detail
C        STRUCTURES:        where they are defined in the code
C                       within include files.
C
C INCLUDE FILES:
C     Name                    Description
C   ---------------   ------------------------------------------------
C   v_data.h         common variables used for verobs
C
C COMPILER DEPENDENCIES:  f90
C
C COMPILE OPTIONS:   -f fixed -c
C
C MAKEFILE: Located at /a/ops/app/mverif/src/sub/makeverobslib
C         UNICOS make
C
C RECORD OF CHANGES:
C
C <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
C    Initial submission
C
C..............................END PROLOGUE.............................
C
     implicit none
     include 'v_data.h'

c*************************************************************************
```

```
c   Formal parameters
c************************************************************************
    character(24), intent(in)  :: seq_type
    Character(32), Intent(in)  :: PARAM       ! parameter
    Real,          Intent(in)  :: lvl        ! level
    CHARACTER(24), INTENT(IN)  :: DSETNM     ! Data set name used.
    CHARACTER(10), INTENT(IN)  :: DTG        ! Date Time Group for read.
    REAL,          INTENT(IN)  :: MINLAT     ! South latitude boundary.
    REAL,          INTENT(IN)  :: MAXLAT     ! North latitude boundary.
    REAL,          INTENT(IN)  :: MINLON     ! West longitude boundary.
    REAL,          INTENT(IN)  :: MAXLON     ! East longitude boundary.
    CHARACTER(24), INTENT(IN)  :: TYPLVL     ! type level, e.g, isbr_lvl
    Real                       :: obslat(maxobs)  ! obs lat
    Real                       :: obslon(maxobs)  ! obs lon
    Real                       :: obsval(maxobs)  ! obs data value
    integer                    :: nobs           ! numober of obs
    integer                    :: istat

c************************************************************************
!   Local variables used as arguments for LLT read subroutines:
c************************************************************************
    CHARACTER(8)  :: VRSNNAM     ! Version of ISIS software used.
    CHARACTER(8)  :: SECLVL      ! 7 character security classification level.
    REAL          :: HR          ! Hour cited in the report.
    CHARACTER(16) :: MINDTG      ! Minmum date and time group to read.
    CHARACTER(16) :: MAXDTG      ! Maximum date and time group to read.
    CHARACTER(16) :: NEW_DTG     ! -12 DTG if current not found
    REAL          :: MINHR       ! Minmum hour to read.
    REAL          :: MAXHR       ! Maximum hour to read.

c************************************************************************
c   Local variables
c************************************************************************
    integer       :: i

    REAL          :: PLAT       ! Point latitude
    REAL          :: PLON       ! Point longitude
    REAL          :: DISTANCE   ! Radius of circle centered
                                ! at PLAT/PLON
    CHARACTER(5)  :: BLOCK_STATION(10)
    CHARACTER(20) :: STATION_NAME(10)  ! International blksta #
    Character(20) :: stn_name

    vrsnnam = '*'
    seclvl  = 'UNCLASS'

c************************************************************************
c   initialize the arrays oblat, oblon, obval
c************************************************************************
    do i=1,maxobs
      obslat(i) = bad_value
      obslon(i) = bad_value
      obsval(i) = bad_value
    end do

c************************************************************************
c   RAOB_QC LLT (nogaps, noraps, coamps
c************************************************************************
    if (seq_type == 'raob_qc') then
      CALL RAOB_QC_READ(vrsnnam,      dsetnm,       seclvl,
   2              dtg,        param,       lvl,
   3              minlat,     maxlat,      minlon,
   4              maxlon,     obslat,      obslon,
   5              nobs,       obsval,      istat)

c************************************************************************
c   sfc_lnd (nogaps, noraps, coamps
c************************************************************************
    else if (seq_type == 'sfc_lnd') then
      CALL SFC_LND_READ(vrsnnam,      dsetnm,       seclvl,
   2              dtg,        param,       lvl,
   3              minlat,     maxlat,      minlon,
   4              maxlon,     obslat,      obslon,
   5              nobs,       obsval,      istat)

c************************************************************************
c   sfc_ship (wam_global, otis_global
c************************************************************************
    else if (seq_type == 'sfc_ship') then
      CALL SFC_SHIP_READ(vrsnnam,      dsetnm,       seclvl,
   2              dtg,        param,       lvl,
   3              minlat,     maxlat,      minlon,
   4              maxlon,     obslat,      obslon,
   5              nobs,       obsval,      istat)

c************************************************************************
c   sfc_ship_met_qc (nogaps, noraps, coamps
c************************************************************************
    else if (seq_type == 'sfc_ship_met_qc') then
      CALL SFC_SHIP_MET_QC_READ
   2              (vrsnnam,    dsetnm,      seclvl,
   3              dtg,        param,       lvl,
   4              minlat,     maxlat,      minlon,
   5              maxlon,     obslat,      obslon,
   6              nobs,       obsval,      istat)

c************************************************************************
c   alty (wam_global
c************************************************************************
    else if (seq_type == 'alty') then
      CALL ALTY_READ(  vrsnnam,     dsetnm,       seclvl,
   2              dtg,        param,       lvl,
   3              minlat,     maxlat,      minlon,
   4              maxlon,     obslat,      obslon,
  5              nobs,      obsval,      istat)

c   other seq_types

    end if

    return
    end subroutine lltread
```

10. alty.f90

```
    subroutine alty_read(vrsnnam, dsetnm, seclvl, dtg,    param,
  2              lvl,    minlat, maxlat, minlon, maxlon,
  3              lat,    lon,   nobs,   obs,    istat)
C
C............................START PROLOGUE...........................
C
C  SCCS IDENTIFICATION: @(#)alty.f90 1.1 04/24/98  /h/cm/library/mverif/src/sub/alty.f90_v
C
C  CONFIGURATION IDENTIFICATION:   NONE
C
C  MODULE NAME:  alty_read
C
C  DESCRIPTION:  subroutine to read the alty data and pick
C            out the obs data for the given parameter
C
C  COPYRIGHT:              (c) 1998 FLENUMMETOCCEN
C                       U.S. GOVERNMENT DOMAIN
C                       ALL RIGHTS RESERVED
C
C  CONTRACT NUMBER AND TITLE:  N/A
C
C  REFERENCES: NONE
C
C  CLASSIFICATION:  Unclassified
C
C  RESTRICTIONS:   NONE
C
C  COMPUTER/OPERATING SYSTEM
C           DEPENDENCIES:  Cray UNICOS
C
C  LIBRARIES OF RESIDENCE:   /a/ops/bin
C
C  USAGE:
C   call alty_read(   vrsnnam, dsetnm, seclvl, dtg,    param,
C                 lvl,    minlat, maxlat, minlon, maxlon,
C                 lat,    lon,   nobs,   obs,    istat)
C
C  PARAMETERS:
C     Name         Type       Usage        Description
C   ----------    ----------   -------  ----------------------------
```

```
C   VRSNNAM      CHAR*8      INPUT    llt version name
C   DSETNM       CHAR*24     INPUT    data set name
C   SECLVL       CHAR*8      INPUT    classification
C   DTG          CHAR*10     INPUT    date time group for read
C   PARAM        CHAR*32     INPUT    parameter
C   LVL          REAL        INPUT    level type
C   MINLAT       REAL        INPUT    minimum latitude
C   MAXLAT       REAL        INPUT    maximum latitude
C   MINLON       REAL        INPUT    minimum longitude
C   MAXLON       REAL        INPUT    maximum longitude
C   LAT          REAL(size)  OUTPUT   obs latitude
C   LON          REAL(size)  OUTPUT   obs longitude
C   NOBS         INTEGER     OUTPUT   number of obs
C   OBS          REAL(size)  OUTPUT   obs value
C   ISTAT        INTEGER     OUTPUT   return status
C
C  COMMON BLOCKS: N/A
C
C  FILES: None
C
C  DATA BASES: ISIS LLT_DB
C     Name        Table      Usage       Description
C   ----------  ---------------  ---------  -------------------------
C    alty       ALTY          IN        alty obs
C
C  NON-FILE INPUT/OUTPUT: N/A
C
C  ERROR CONDITIONS:
C       CONDITION              ACTION
C   -----------------      ----------------------------
C   DTG error              Print err message & return
C   Error return from LRD      Print err message
C   Error return from LCLOS    Print err message
C
C  ADDITIONAL COMMENTS:   NONE
C
C....................MAINTENANCE SECTION................................
C
C  MODULES CALLED:
C        Name       Description
C       -------    -----------------------
C       LCLOS      ISIS LLT close
C       LEN_TRIM   Determines the length of a string
C       LRD        ISIS LLT read
C       TRIM       Removes the trailing blanks
C
C  LOCAL VARIABLES AND       Structures are documented in detail
C         STRUCTURES:        where they are defined in the code
C                     within include files.
C
C  METHOD:
C    Set seq_type to 'alty'
```

```
C    See raob_qc_read for the rest.
C
C  INCLUDE FILES:
C      Name                    Description
C   ---------------    ----------------------------------------------
C    ALTY.H            alty header file
C
C  COMPILER DEPENDENCIES:  f90
C
C  COMPILE OPTIONS:  -f fixed -c
C
C  MAKEFILE:  Located at /a/ops/app/mverif/src/sub/makeverobslib
C            UNICOS make
C
C  RECORD OF CHANGES:
C
C  <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
C     Initial submission
C
C..............................END PROLOGUE.............................
C
      implicit none
      include 'v_data.h'
      include 'ALTY.H'

c***********************************************************************
c    formal parameters
c***********************************************************************
      character(8),  intent(in) :: vrsnnam
      character(24), intent(in) :: dsetnm
      character(8),  intent(in) :: seclvl
      character(10), intent(in) :: dtg
      character(32), intent(in) :: param
      real,          intent(in) :: lvl
      real,          intent(in) :: minlat
      real,          intent(in) :: maxlat
      real,          intent(in) :: minlon
      real,          intent(in) :: maxlon
      real                      :: lat(size)
      real                      :: lon(size)
      integer                   :: nobs
      real                      :: obs(size)
      integer                   :: istat

c***********************************************************************
c    local variables used as arguments for LRD:
c***********************************************************************
      character(24) :: seq_type
      real          :: hr
      CHARACTER(16) :: MINDTG     ! Minmum date and time group to read.
      CHARACTER(16) :: MAXDTG     ! Maximum date and time group to read.
      REAL          :: MINHR      ! Minmum hour to read.
      REAL         :: MAXHR     ! Maximum hour to read.
      CHARACTER(16) :: RSN_IN    ! Reporting source name.
      REAL         :: FCST_IN   ! Desired forecast "TAU".
      CHARACTER(24) :: MINUPTM   ! Minimum update time.
      CHARACTER(56) :: REMARKS   ! Description of data/assoc. record.
      CHARACTER(16) :: RPT_DTG   ! Actual date & time group for report.
      REAL         :: RPT_HR    ! Reported hour read.
      REAL         :: RPT_LAT   ! Reported latitude read.
      REAL         :: RPT_LON   ! Reported longitude read.
      CHARACTER(16) :: RPT_RSN   ! Reported longitude read.
      REAL         :: RPT_FCST  ! Reported "TAU" or forecast time.
      CHARACTER(24) :: RPT_CRETM ! Record creation date.
      CHARACTER(24) :: RPT_UDT   ! Report's last update time.
      INTEGER       :: BUFFLAG   ! 0 => Input is in FBUFF
                       ! 1 => Input is in IBUFF
      INTEGER       :: LLT_ID    ! Unique database LLT identifier for each
                       ! dataset.
      INTEGER       :: BLKSEQID  ! Unique database LLT block identifier.
      INTEGER       :: RECSEQID  ! Unique database LLT record identifier.

      TYPE(alty_int):: IBUFF     ! integer record structure.
      TYPE(alty):: FBUFF         ! Real record structure.

c*********************************************************************
c   Arguments for  LCLOS  (that get "*" for values).
c*********************************************************************
      CHARACTER(24) :: SEQTYPE_X  ! Report type.
      CHARACTER(8)  :: VRSNNAM_X  ! Version of ISIS software used.
      CHARACTER(24) :: DSETNAM_X  ! Data set name used.
      CHARACTER(8)  :: SECLVL_X   ! 7 character security
                       ! classification level.
      CHARACTER(16) :: DTG_X      ! Date Time Group for write.

c*********************************************************************
c   Other local variables
c*********************************************************************
      integer :: levels
      integer :: status, i, status2

      seq_type = 'alty' ! Report type
      istat = 0

!*********************************************************************
!   Set up date and time group in YYYYMMDDHH format in DTG.
!*********************************************************************
      IF ( LEN_TRIM(DTG) == 10 ) THEN
        READ (UNIT=DTG(9:10),FMT='(F2.0)',IOSTAT=STATUS) HR
        IF ( STATUS == 0 ) THEN
          IF ( HR < 12. ) THEN
            HR = 0.
          ELSE
            HR = 12.
          END IF
        ELSE
          WRITE *, ' Cannot read hour "', DTG(9:10),
     2            ' from date & time group ', TRIM(DTG)
          istat = -1
          RETURN
        END IF
      ELSE
        STATUS = 10
        WRITE *, 'alty: Got date and time group ',
     2          TRIM(DTG), ' of length ',
     3          LEN_TRIM(DTG), ' but expected length == 10.'
        istat = -1
        RETURN
      END IF

!********************************************************************
!   Set the input parameters used to get a read-back value.
!********************************************************************
      MINDTG   = DTG;     MAXDTG   = DTG
      MINHR    = HR;      MAXHR    = HR+11.999
      RSN_IN   = '*'
      FCST_IN  = 0.0   ! Report forecast period or Tau (normal = 0.0)
      MINUPTM  = '*'
      BUFFLAG = 0      !  Want (both) floating (and integer).

!********************************************************************
!   get the data from LLT db
!********************************************************************
      I = 0
      nobs = 0

      DO WHILE ( STATUS == 0 )
        CALL LRD(seq_type,  vrsnnam,  dsetnm,    SECLVL,
     2        MINDTG,  MINHR,   MAXDTG,    MAXHR,
     3        MINLAT,  MAXLAT,  MINLON,    MAXLON,
     4        RSN_IN,  FCST_IN,  MINUPTM,   BUFFLAG,
     5        RPT_DTG,  RPT_HR,   RPT_LAT,   RPT_LON,
     6        RPT_RSN,  RPT_FCST,  RPT_CRETM,  RPT_UDT,
     7        LLT_ID,   BLKSEQID,  RECSEQID,
     8        IBUFF,    FBUFF,     STATUS )
        IF ( STATUS /= 0 ) THEN
          IF ( STATUS /= 100 ) THEN
            ! Ignore normal no-more-data return code
            WRITE *, ' Read from ISIS failed.  Code = ', STATUS, '.'
            istat = status
          END IF
        ELSE  ! successful LRD
          I = I + 1

c*************************************************************************
c       pick out the relevant info and fill the array
```

```
c***************************************************************************
        if (param == 'sig_wav_ht') then
          if (fbuff % sig_wav_ht < check_val) then
            nobs = nobs + 1
            lat(nobs) = fbuff % crse_lat
            lon(nobs) = fbuff % crse_lon
            obs(nobs) = fbuff % sig_wav_ht
          end if

        else if (param == 'wnd_spd') then
          if (fbuff % wnd_spd < check_val) then
            nobs = nobs + 1
            lat(nobs) = fbuff % crse_lat
            lon(nobs) = fbuff % crse_lon
            obs(nobs) = fbuff % wnd_spd
          end if

        end if ! param
      end if   ! OK status
    END DO     ! i loop

    IF ( STATUS == 100 )  STATUS = 0
    write *, ' '
    WRITE *, ' Called LRD ', I, ' times.'
    write *, ' Read ', nobs, ' obs of sequence type ', TRIM(SEQ_TYPE),
   2       '.'

!***************************************************************************
!   Close the dataset (now open for reading) again.
!***************************************************************************
    SEQTYPE_X = '*' ;  VRSNNAM_X = '*' ;  DSETNAM_X = '*'
    SECLVL_X  = '*' ;  DTG_X     = '*'

    CALL LCLOS(SEQTYPE_X, VRSNNAM_X, DSETNAM_X,
   2         SECLVL_X, DTG_X, STATUS2)
    IF ( STATUS2 /= 0 ) THEN
      WRITE *, ' Could not close ISIS table. ',
   2         ' Error code is ', STATUS2, '.'
    END IF

    return
    end subroutine alty_read
```

11. raob_qc.f90

```
    subroutine raob_qc_read(vrsnnam, dsetnm, seclvl, dtg, param,
   2                  lvl, minlat, maxlat, minlon, maxlon,
   3                  lat, lon, kfinal, obs, istat)
c
c............................START PROLOGUE............................
c
```

```
c SCCS IDENTIFICATION: @(#)raob_qc.f90 1.1 04/24/98 /h/cm/library/mverif/src/sub/raob_qc.f90_v
c
c CONFIGURATION IDENTIFICATION:  NONE
c
c MODULE NAME:  raob_qc_read
c
c DESCRIPTION:  subroutine to read the raob_qc data and pick
c           out the obs data for the given parameter
c
c COPYRIGHT:              (c) 1996 FLENUMMETOCCEN
c                    U.S. GOVERNMENT DOMAIN
c                    ALL RIGHTS RESERVED
c
c CONTRACT NUMBER AND TITLE:  N/A
c
c REFERENCES: LLT User's Manual
c
c CLASSIFICATION:  Unclassified
c
c RESTRICTIONS:  NONE
c
c COMPUTER/OPERATING SYSTEM
c         DEPENDENCIES:  Cray UNICOS
c
c LIBRARIES OF RESIDENCE: /a/ops/bin
c
c USAGE:
c  call raob_qc_read(vrsnnam, dsetnm, seclvl, dtg, param,
c              level, minlat, maxlat, minlon, maxlon,
c              lat, lon, kfinal, obs, istat)
c
c PARAMETERS:
c    Name        Type      Usage       Description
c  ----------   ----------   ------- ----------------------------
c  VRSNNAM      INTEGER      INPUT   Version name
c  DSETNM       CHAR*24      INPUT   ISIS dataset name
c  SECLVL       CHAR*8       INPUT   Security level
c  DTG          CHAR*10      INPUT   Date Time Group for read
c  PARAM        CHAR*32      INPUT   Parameter to read eg. air_temp
c  LVL          REAL         INPUT   Pressure level
c  MINLAT       REAL         INPUT   Minimum latitude of the area
c  MAXLAT       REAL         INPUT   Maximum latitude of the area
c  MINLON       REAL         INPUT   Minimum longitude of the area
c  MAXLON       REAL         INPUT   Maximum longitude of the area
c  LAT          Real(size)   OUTPUT  obs latitude
c  LON          Real(size)   OUTPUT  obs longtitude
c  KFINAL       INTEGER      OUTPUT  Number of obs
c  OBS          Real(size)   OUTPUT  Observed parameter value
c  ISTAT        INTEGER      OUTPUT  Status
c
c COMMON BLOCKS: N/A
c
```

```
c FILES:  None
c
c DATA BASES: ISIS LLT database
c
c     Name          Table      Usage          Description
c   ----------    -------------- ---------   -------------------------
c   raob_qc       RAOB_QC          IN        raob obs
c
c NON-FILE INPUT/OUTPUT: N/A
c
c ERROR CONDITIONS:
c       CONDITION              ACTION
c    -----------------       ----------------------------
c  DTG error                 Print err message & return
c  Error return from LRD     Print err message
c  Error return from LCLOS   Print err message
c
c...................MAINTENANCE SECTION...............................
c
c MODULES CALLED:
c        Name          Description
c       -------     ----------------------
c       LCLOS       ISIS LLT close
c       LEN_TRIM    Determines the length of a string
c       LRD         ISIS LLT read
c       TRIM        Removes the trailing blanks
c
c LOCAL VARIABLES AND        Structures are documented in detail
c        STRUCTURES:       where they are defined in the code
c                       within include files.
c
c METHOD:
c    1. Set seq_type to 'raob_qc'
c
c    2. Get hr from dtg, set mindtg, maxdtg, minhr, maxhr, rsn_in
c      (reporting source name), fcst_in (desired tau), minuptm
c      (min update time), bufflag (0)
c
c    3. Set i=0
c
c      do while (status == 0)
c        call LRD(seq_type, vrsnnam,  dsetnam,   seclvl,  mindtg,
c              minhr,   maxdtg,   maxhr,    minlat,  maxlat,
c              minlon,   maxlon,   rsn_in,    fcst_in, minuptm,
c              bufflag,  rpt_dtg,  rtp_hr,    rpt_lat, rpt_lon,
c              rpt_rsn,  rpt_fcst, rpt_cretm, rpt_udt, llt_id,
c              blkseqid, recseqid, ibuff,      fbuff,    status)
c        if status /= 0 then
c          if status /= 100 then
c            write error msg
c          end if
c        else
```

```
c        i = i + 1
c        if duplicate data using rpt_rsn
c          print msg
c        endif
c
c        ==================================================
c        pick out the relevant info and fill the array
c        ==================================================
c        nobs = 0
c        levels = fbuff % prof_cnt
c        do j=1, levels
c          ==============================================
c          pick out only the right level
c          ==============================================
c          if (prof_t % pres == level) then
c
c            lat(j) = fbuff % crse_lat
c            lon(j) = fbuff % crse_lon
c            if parm = 'air_temp' then
c              if prof_t % air_temp /= missing_value then
c                obs(j) = prof_t % air_temp
c                nobs = nobs + 1
c              endif
c            elseif parm = 'geop_ht' then
c              if prof_t % geop_ht /= missing_value then
c                obs(j) = prof_t % geop_ht
c                nobs = nobs + 1
c              endif
c            elseif parm = 'wnd_dir' then
c              if prof_t % wnd_dir /= missing_value then
c                obs(j) = prof_t % wnd_dir
c                nobs = nobs + 1
c              endif
c            elseif parm = 'wnd_spd' then
c              if prof_t % wnd_spd /= missing_value then
c                obs(j) = prof_t % wnd_spd
c                nobs = nobs + 1
c              endif
c            endif
c
c          endif (right level)
c        enddo (j loop)
c
c      endif c if status=0
c    enddo c i loop
c
c    if (status = 100) then status is good
c    close the dataset by calling LCLOS
c
c INCLUDE FILES:
c   Name                   Description
c  ---------------   ------------------------------------------------
```

```
c  RAOB_QC.H       raob header file
c  common.inc      LLT data structure
c  v_data.h        common variables for verobs
c
c COMPILER DEPENDENCIES:  f90
c
c COMPILE OPTIONS:  -f fixed -c
c
c MAKEFILE: Located at /a/ops/app/mverif/src/sub/makeverobslib
c        UNICOS make
c
c RECORD OF CHANGES:
c
c <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
c   Initial submission
c
c..............................END PROLOGUE.............................
c
   implicit none

   include 'v_data.h'
   include 'common.inc'
   include 'RAOB_QC.H'

c***********************************************************************
c   formal parameters
c***********************************************************************
   character(8),  intent(in) :: vrsnnam
   character(24), intent(in) :: dsetnm
   character(8),  intent(in) :: seclvl
   character(10), intent(in) :: dtg
   character(32), intent(in) :: param
   real,       intent(in) :: lvl
   real,       intent(in) :: minlat
   real,       intent(in) :: maxlat
   real,       intent(in) :: minlon
   real,       intent(in) :: maxlon
   real                   :: lat(size)
   real                   :: lon(size)
   integer                :: kfinal
   real                   :: obs(size)
   integer                :: istat

c***********************************************************************
c   local variables used as arguments for LRD:
c***********************************************************************
   character(24) :: seq_type
   real       :: hr
   CHARACTER(16) :: MINDTG    ! Minmum date and time group to read.
   CHARACTER(16) :: MAXDTG    ! Maximum date and time group to read.
   REAL       :: MINHR     ! Minmum hour to read.
   REAL       :: MAXHR     ! Maximum hour to read.
```

```
      CHARACTER(16) :: RSN_IN    ! Reporting source name.
      REAL          :: FCST_IN   ! Desired forecast "TAU".
      CHARACTER(24) :: MINUPTM   ! Minimum update time.
      CHARACTER(56) :: REMARKS   ! Description of data/assoc. record.
      CHARACTER(16) :: RPT_DTG   ! Actual date & time group for report.
      REAL          :: RPT_HR    ! Reported hour read.
      REAL          :: RPT_LAT   ! Reported latitude read.
      REAL          :: RPT_LON   ! Reported longitude read.
      CHARACTER(16) :: RPT_RSN   ! Reported longitude read.
      REAL          :: RPT_FCST  ! Reported "TAU" or forecast time.
      CHARACTER(24) :: RPT_CRETM ! Record creation date.
      CHARACTER(24) :: RPT_UDT   ! Report's last update time.
      INTEGER       :: BUFFLAG   ! 0 => Input is in FBUFF
                                 ! 1 => Input is in IBUFF
      INTEGER       :: LLT_ID    ! Unique database LLT identifier for each
                                 ! dataset.
      INTEGER       :: BLKSEQID  ! Unique database LLT block identifier.
      INTEGER       :: RECSEQID  ! Unique database LLT record identifier.

      TYPE(raob_qc_int) :: IBUFF
      TYPE(raob_qc) :: FBUFF     ! Real record structure.

c*********************************************************************
c   Arguments for  LCLOS  (that get "*" for values).
c*********************************************************************
      CHARACTER(24) :: SEQTYPE_X  ! Report type.
      CHARACTER(8)  :: VRSNNAM_X  ! Version of ISIS software used.
      CHARACTER(24) :: DSETNAM_X  ! Data set name used.
      CHARACTER(8)  :: SECLVL_X   ! 7 character security
                                  ! classification level.
      CHARACTER(16) :: DTG_X      ! Date Time Group for write.

c*********************************************************************
c   Other local variables
c*********************************************************************
      integer :: levels, lvl_1, nmatch, k
      integer :: status, i, j, status2

      seq_type = 'raob_qc' ! obs report type
      istat = 0

c*********************************************************************
c   Set up date and time group in YYYYMMDDHH format in DTG.
c*********************************************************************
      IF ( LEN_TRIM(DTG) == 10 ) THEN
        READ (UNIT=DTG(9:10),FMT='(F2.0)',IOSTAT=STATUS) HR
        IF ( STATUS == 0 ) THEN
          IF ( HR < 12. ) THEN
            HR = 0.
          ELSE
            HR = 12.
          END IF
        ELSE
          WRITE *, ' Cannot read hour ', DTG(9:10),
     2           ' from date & time group ', TRIM(DTG)
          istat = -1
          RETURN
        END IF
      ELSE
        STATUS = 10
        WRITE *,'raob_qc: Got date and time group ', TRIM(DTG),
     2        'of length ',
     3         LEN_TRIM(DTG), ' but expected length == 10.'
        istat = -1
        RETURN
      END IF

c********************************************************************
c    Set the input parameters used to get a read-back value.
c********************************************************************
      MINDTG   = DTG;     MAXDTG   = DTG
      MINHR    = HR;      MAXHR    = HR+11.999
      RSN_IN   = '*'
      FCST_IN  = 0.0   ! Report forecast period or Tau (normal = 0.0)
      MINUPTM  = '*'
      BUFFLAG  = 0     !  Want (both) floating (and integer).

c********************************************************************
c    get the data from LLT db
c********************************************************************
      I = 0
      kfinal = 0 ! overall number of matched pressure level and param

      DO WHILE ( STATUS == 0 )
        CALL LRD(seq_type, vrsnnam,  dsetnm,    SECLVL,
     2         MINDTG,  MINHR,   MAXDTG,   MAXHR,
     3         MINLAT,  MAXLAT,  MINLON,   MAXLON,
     4         RSN_IN,  FCST_IN, MINUPTM,  BUFFLAG,
     5         RPT_DTG, RPT_HR,  RPT_LAT,  RPT_LON,
     6         RPT_RSN, RPT_FCST, RPT_CRETM, RPT_UDT,
     7         LLT_ID,  BLKSEQID, RECSEQID,
     8         IBUFF,   FBUFF,   STATUS )
        IF ( STATUS /= 0 ) THEN
          IF ( STATUS /= 100 ) THEN
            ! Ignore normal no-more-data return code
            WRITE *, ' Read from ISIS failed.  Code = ', STATUS, '.'
            istat = -1
          END IF
        ELSE  ! successful LRD
          I = I + 1

c*************************************************************************
c       pick out the relevant info and fill the array
c       prof is a sub-structure of raob_qc
```

```
c     prof_cnt has the number of levels
c**************************************************************************
      levels = fbuff % prof_cnt

      do j = 1, levels

c**************************************************************************
c     pick out only the right level
c**************************************************************************

       nmatch = 0 ! number of matched pressure level and parameter

       lvl_1 = int(fbuff % prof(j) % pres / 100)
       if (lvl_1 == lvl) then

c**************************************************************************
c        we want to use the qc flag to discard the bad obs
c        use the qc flag value of 1 for this obs type
c**************************************************************************
        if (param == 'air_temp') then
         if (fbuff%prof(j)%air_temp_qc_id == 1 .and.
     2     fbuff%prof(j)%air_temp < check_val) then

c**************************************************************************
c           want to fill the lat, lon, obs arrays filled from
c           1 to overall number of matched obs without any
c           skipped indices
c           j index is for the level_cnt for a given lat/lon,*
c           k index is for the matched param and pressure level
c           within the j index
c**************************************************************************
          nmatch = nmatch + 1
          do k = kfinal+1, kfinal+nmatch
           lat(k) = fbuff % crse_lat
           lon(k) = fbuff % crse_lon
           obs(k) = (fbuff % prof(j) % air_temp)
          end do
         end if

        else if (param == 'geop_ht') then
         if (fbuff%prof(j)%geop_ht_qc_id == 1 .and.
     2     fbuff%prof(j)%geop_ht < check_val) then
          nmatch = nmatch + 1
          do k = kfinal+1, kfinal+nmatch
           lat(k) = fbuff % crse_lat
           lon(k) = fbuff % crse_lon
           obs(k) = fbuff % prof(j) % geop_ht
          end do
         end if

        else if (param == 'wnd_dir') then
         if (fbuff%prof(j)%wnd_qc_id == 1 .and.
     2             fbuff%prof(j)%dir < check_val) then
                  nmatch = nmatch + 1
                  do k = kfinal+1, kfinal+nmatch
                    lat(k) = fbuff % crse_lat
                    lon(k) = fbuff % crse_lon
                    obs(k) = fbuff % prof(j) % dir
                  end do
                end if

              else if (param == 'wnd_spd') then
                if (fbuff%prof(j)%wnd_qc_id == 1 .and.
     2             fbuff%prof(j)%spd < check_val) then
                  nmatch = nmatch + 1
                  do k = kfinal+1, kfinal+nmatch
                    lat(k) = fbuff % crse_lat
                    lon(k) = fbuff % crse_lon
                    obs(k) = fbuff % prof(j) % spd
                  end do
                end if

              end if ! param
            end if  ! right level
            kfinal = kfinal + nmatch
          end do  ! levels loop
        end if   ! OK status
      end do     ! i loop
      if (status == 100) status = 0
      write *, ' '
      write *, ' Called LRD ', I, ' times.'
      write *, ' Read ', kfinal, ' obs of sequence type ',
     2      TRIM(seq_type), '.'

c*************************************************************************
c     Close the dataset (now open for reading) again.
c*************************************************************************
      SEQTYPE_X = '*' ;  VRSNNAM_X = '*' ;  DSETNAM_X = '*'
      SECLVL_X  = '*' ;  DTG_X     = '*'

      CALL LCLOS(SEQTYPE_X, VRSNNAM_X, DSETNAM_X,
     2        SECLVL_X, DTG_X,     STATUS2)
      if (STATUS2 /= 0) then
        write *, ' Could not close ISIS table. ',
     2          ' Error code is ', STATUS2, '.'
      end if

      return
      end subroutine raob_qc_read
```

12. sfcland.f90

```
      subroutine sfc_lnd_read(vrsnnam, dsetnm, seclvl, dtg,    param,
     2              lvl,   minlat, maxlat, minlon, maxlon,
     3              lat,   lon,   nobs,   obs,   istat)
C
C..............................START PROLOGUE..............................
C
C SCCS IDENTIFICATION: @(#)sfcland.f90 1.1 04/24/98 /h/cm/library/mverif/src/sub/sfcland.f90_v
C
C  CONFIGURATION IDENTIFICATION:   NONE
C
C  MODULE NAME:  sfc_lnd_read
C
C  DESCRIPTION:  subroutine to read the sfc_land data and pick out the
C           obs data for the given parameter
C
C  COPYRIGHT:              (c) 1996 FLENUMMETOCCEN
C                       U.S. GOVERNMENT DOMAIN
C                       ALL RIGHTS RESERVED
C
C  CONTRACT NUMBER AND TITLE:   N/A
C
C  REFERENCES: NONE
C
C  CLASSIFICATION:   Unclassified
C
C  RESTRICTIONS:   NONE
C
C  COMPUTER/OPERATING SYSTEM
C           DEPENDENCIES:  Cray UNICOS
C
C  LIBRARIES OF RESIDENCE:  /a/ops/bin
C
C  USAGE:
C   call sfc_land(vrsnnam, dsetnm, seclvl, dtg, param,
C           lvl, minlat, maxlat, minlon, maxlon,
C           lat, lon, nobs, obs, istat)
C
C  PARAMETERS:
C     Name        Type       Usage        Description
C   ----------   ----------  -------  ----------------------------
C   VRSNNAM      CHAR*8      INPUT    llt version name
C   DSETNM       CHAR*24     INPUT    data set name
C   SECLVL       CHAR*8      INPUT    classification
C   DTG          CHAR*10     INPUT    date time group for read
C   PARAM        CHAR*32     INPUT    parameter
C   LVL          REAL        INPUT    level type
C   MINLAT       REAL        INPUT    minimum latitude
C   MAXLAT       REAL        INPUT    maximum latitude
C   MINLON       REAL        INPUT    minimum longitude
C   MAXLON       REAL        INPUT    maximum longitude
C   LAT          REAL(size)  OUTPUT   obs latitude
C   LON          REAL(size)  OUTPUT   obs longitude
C   NOBS         INTEGER     OUTPUT   number of obs
```

```
C  OBS           REAL(size)    OUTPUT    obs value
C  ISTAT          INTEGER       OUTPUT    status code
C
C COMMON BLOCKS: N/A
C
C FILES: None
C
C DATA BASES:  ISIS LLT_DB
C     Name          Table      Usage          Description
C   ----------   --------------  ---------   -------------------------
C   sfc_lnd        SFC_LND      IN          surface land obs
C
C NON-FILE INPUT/OUTPUT: N/A
C
C ERROR CONDITIONS:
C       CONDITION              ACTION
C   -----------------      ----------------------------
C  DTG error               Print err message & return
C  Error return from LRD     Print err message
C  Error return from LCLOS    Print err message
C
C ADDITIONAL COMMENTS:   NONE
C
C...................MAINTENANCE SECTION................................
C
C MODULES CALLED:
C        Name          Description
C        -------    ----------------------
C        LCLOS      ISIS LLT close
C        LEN_TRIM   Determines the length of a string
C        LRD        ISIS LLT read
C        TRIM       Removes the trailing blanks
C
C LOCAL VARIABLES AND        Structures are documented in detail
C         STRUCTURES:      where they are defined in the code
C                          within include files.
C
C METHOD:
C    Set seq_type to 'sfc_lnd'
C    See raob_qc.f90 for the rest.
C
C INCLUDE FILES:
C     Name                    Description
C   ---------------    -----------------------------------------------
C   SFC_LND.H        surface land header file
C   V_DATA.H         common variables for verobs
C
C COMPILER DEPENDENCIES:  f90
C
C COMPILE OPTIONS:  -f fixed -c
C
C MAKEFILE: Located at /a/ops/app/mverif/src/sub/makeverobslib
```

```
C        UNICOS make
C
C  RECORD OF CHANGES:
C
C  <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
C    Initial submission
C
C..............................END PROLOGUE............................
C
    implicit none
    include 'v_data.h'
    include 'SFC_LND.H'

c**********************************************************************
c   formal parameters
c**********************************************************************
    character(8),  intent(in) :: vrsnnam
    character(24), intent(in) :: dsetnm
    character(8),  intent(in) :: seclvl
    character(10), intent(in) :: dtg
    character(32), intent(in) :: param
    real,        intent(in) :: lvl
    real,        intent(in) :: minlat
    real,        intent(in) :: maxlat
    real,        intent(in) :: minlon
    real,        intent(in) :: maxlon
    real                    :: lat(size)
    real                    :: lon(size)
    integer                 :: nobs
    real                    :: obs(size)
    integer                 :: istat

c**********************************************************************
c   local variables used as arguments for LRD:
c**********************************************************************
    character(24) :: seq_type
    real          :: hr
    CHARACTER(16) :: MINDTG    ! Minmum date and time group to read.
    CHARACTER(16) :: MAXDTG    ! Maximum date and time group to read.
    REAL          :: MINHR     ! Minmum hour to read.
    REAL          :: MAXHR     ! Maximum hour to read.
    CHARACTER(16) :: RSN_IN    ! Reporting source name.
    REAL          :: FCST_IN   ! Desired forecast "TAU".
    CHARACTER(24) :: MINUPTM   ! Minimum update time.
    CHARACTER(56) :: REMARKS   ! Description of data/assoc. record.
    CHARACTER(16) :: RPT_DTG   ! Actual date & time group for report.
    REAL          :: RPT_HR    ! Reported hour read.
    REAL          :: RPT_LAT   ! Reported latitude read.
    REAL          :: RPT_LON   ! Reported longitude read.
    CHARACTER(16) :: RPT_RSN   ! Reported longitude read.
    REAL          :: RPT_FCST  ! Reported "TAU" or forecast time.
    CHARACTER(24) :: RPT_CRETM ! Record creation date.
```

```
      CHARACTER(24) :: RPT_UDT    ! Report's last update time.
      INTEGER       :: BUFFLAG    ! 0 => Input is in FBUFF
                                  ! 1 => Input is in IBUFF
      INTEGER       :: LLT_ID     ! Unique database LLT identifier for each
                                  ! dataset.
      INTEGER       :: BLKSEQID   ! Unique database LLT block identifier.
      INTEGER       :: RECSEQID   ! Unique database LLT record identifier.

      TYPE(sfc_lnd_int) :: IBUFF
      TYPE(sfc_lnd) :: FBUFF      ! Real record structure.

c***********************************************************************
c   Arguments for  LCLOS  (that get "*" for values).
c***********************************************************************
      CHARACTER(24) :: SEQTYPE_X  ! Report type.
      CHARACTER(8)  :: VRSNNAM_X  ! Version of ISIS software used.
      CHARACTER(24) :: DSETNAM_X  ! Data set name used.
      CHARACTER(8)  :: SECLVL_X   ! 7 character security
                                  ! classification level.
      CHARACTER(16) :: DTG_X      ! Date Time Group for write.

c***********************************************************************
c   Other local variables
c***********************************************************************
      integer :: levels
      integer :: status, i, status2

      seq_type = 'sfc_lnd' ! Report type
      istat = 0

!***********************************************************************
!   Set up date and time group in YYYYMMDDHH format in DTG.
!***********************************************************************
      IF ( LEN_TRIM(DTG) == 10 ) THEN
        READ (UNIT=DTG(9:10),FMT='(F2.0)',IOSTAT=STATUS) HR
        IF ( STATUS == 0 ) THEN
          IF ( HR < 12. ) THEN
            HR = 0.
          ELSE
            HR = 12.
          END IF
        ELSE
          WRITE *, ' Cannot read hour "', DTG(9:10),
     2           ' from date & time group ', TRIM(DTG)
          istat = -1
          RETURN
        END IF
      ELSE
        STATUS = 10
        WRITE *, 'sfcland: Got date and time group ',
     2         TRIM(DTG), ' of length ',
     3         LEN_TRIM(DTG), ' but expected length == 10.'
```

```
      istat = -1
      RETURN
    END IF

!************************************************************************
!   Set the input parameters used to get a read-back value.
!************************************************************************
    MINDTG   = DTG;      MAXDTG   = DTG
    MINHR    = HR;       MAXHR    = HR+11.999
    RSN_IN   = '*'
    FCST_IN  = 0.0    ! Report forecast period or Tau (normal = 0.0)
    MINUPTM  = '*'
    BUFFLAG = 0       !  Want (both) floating (and integer).

!************************************************************************
!   get the data from LLT db
!************************************************************************
    I = 0
    nobs = 0

    DO WHILE ( STATUS == 0 )
      CALL LRD(seq_type,  vrsnnam,  dsetnm,     SECLVL,
   2         MINDTG,  MINHR,    MAXDTG,     MAXHR,
   3         MINLAT,   MAXLAT,   MINLON,     MAXLON,
   4         RSN_IN,   FCST_IN,  MINUPTM,   BUFFLAG,
   5         RPT_DTG,  RPT_HR,    RPT_LAT,    RPT_LON,
   6         RPT_RSN,  RPT_FCST,  RPT_CRETM,  RPT_UDT,
   7         LLT_ID,   BLKSEQID,  RECSEQID,
   8         IBUFF,    FBUFF,    STATUS )
      IF ( STATUS /= 0 ) THEN
        IF ( STATUS /= 100 ) THEN
          ! Ignore normal no-more-data return code
          WRITE *, ' Read from ISIS failed.  Code = ', STATUS, '.'
          istat = status
        END IF
      ELSE  ! successful LRD
        I = I + 1

c***************************************************************************
c        pick out the relevant info and fill the array
c        check for ISIS missing value
c***************************************************************************
        if (param == 'air_temp') then
          if (fbuff % air_temp < check_val .and.
   2         fbuff % air_temp_qc_id == 1) then
            nobs = nobs + 1
            lat(nobs) = fbuff % crse_lat
            lon(nobs) = fbuff % crse_lon
            obs(nobs) = fbuff % air_temp
          end if

        else if (param == 'wnd_dir') then
        if (fbuff % wnd_dir < check_val .and.
 2          fbuff % wnd_qc_id ==1) then
          nobs = nobs + 1
          lat(nobs) = fbuff % crse_lat
          lon(nobs) = fbuff % crse_lon
          obs(nobs) = fbuff % wnd_dir
        end if

      else if (param == 'sea_lvl_pres') then
        if (fbuff % sea_lvl_pres < check_val .and.
 2          fbuff % sea_lvl_pres_qc_id == 1) then
          nobs = nobs + 1
          lat(nobs) = fbuff % crse_lat
          lon(nobs) = fbuff % crse_lon
          obs(nobs) = (fbuff % sea_lvl_pres) / 100.0
        end if

      else if (param == 'wnd_spd') then
        if (fbuff % wnd_spd < check_val .and.
 2          fbuff % wnd_qc_id == 1) then
          nobs = nobs + 1
          lat(nobs) = fbuff % crse_lat
          lon(nobs) = fbuff % crse_lon
          obs(nobs) = fbuff % wnd_spd
        end if

      end if ! param
    end if   ! OK status
  END DO     ! i loop

  IF ( STATUS == 100 )  STATUS = 0

  write *, ' '
  WRITE *, ' Called LRD ', I, ' times.'
  write *, ' Read ', nobs, ' obs of sequence type ', TRIM(SEQ_TYPE),
 2      '.'

!***************************************************************************
!   Close the dataset (now open for reading) again.
!***************************************************************************
  SEQTYPE_X = '*' ;  VRSNNAM_X = '*' ;  DSETNAM_X = '*'
  SECLVL_X  = '*' ;  DTG_X     = '*'

  CALL LCLOS(SEQTYPE_X, VRSNNAM_X, DSETNAM_X,
 2      SECLVL_X, DTG_X, STATUS2)
  IF ( STATUS2 /= 0 ) THEN
    WRITE *, ' Could not close ISIS table. ',
 2        ' Error code is ', STATUS2, '.'
  END IF

  return
  end subroutine sfc_lnd_read
```

13. sfcship.f90

```
   subroutine sfc_ship_read(vrsnnam, dsetnm, seclvl, dtg,    param,
  2                 lvl,    minlat, maxlat, minlon, maxlon,
  3                 lat,    lon,    nobs,   obs,    istat)
C
C............................START PROLOGUE...........................
C
C SCCS IDENTIFICATION: @(#)sfcship.f90 1.1 04/24/98 /h/cm/library/mverif/src/sub/sfcship.f90_v
C
C  CONFIGURATION IDENTIFICATION:   NONE
C
C  MODULE NAME:  sfc_ship_read
C
C  DESCRIPTION:  subroutine to read the sfc_ship data and pick
C            out the obs data for the given parameter
C
C  COPYRIGHT:              (c) 1996 FLENUMMETOCCEN
C                     U.S. GOVERNMENT DOMAIN
C                     ALL RIGHTS RESERVED
C
C  CONTRACT NUMBER AND TITLE:   N/A
C
C  REFERENCES: NONE
C
C  CLASSIFICATION:   Unclassified
C
C  RESTRICTIONS:   NONE
C
C  COMPUTER/OPERATING SYSTEM
C           DEPENDENCIES:  Cray UNICOS
C
C  LIBRARIES OF RESIDENCE:   /a/ops/bin
C
C  USAGE:
C    call sfc_ship_read(vrsnnam, dsetnm, seclvl, dtg,    param,
C                 lvl,    minlat, maxlat, minlon, maxlon,
C                 lat,    lon,    nobs,   obs,    istat)
C
C  PARAMETERS:
C     Name          Type        Usage          Description
C    ----------    ----------    -------  ----------------------------
C    VRSNNAM       CHAR*8       INPUT    llt version name
C    DSETNM       CHAR*24      INPUT    data set name
C    SECLVL       CHAR*8       INPUT    classification
C    DTG          CHAR*10      INPUT    date time group for read
C    PARAM        CHAR*32      INPUT    parameter
C    LVL         REAL         INPUT    level type
C    MINLAT       REAL         INPUT    minimum latitude
C    MAXLAT        REAL         INPUT    maximum latitude
C    MINLON       REAL         INPUT    minimum longitude
```

```
C  MAXLON      REAL        INPUT    maximum longitude
C  LAT         REAL(size)  OUTPUT   obs latitude
C  LON         REAL(size)  OUTPUT   obs longitude
C  NOBS        INTEGER     OUTPUT   number of obs
C  OBS         REAL(size)  OUTPUT   obs value
C  ISTAT       INTEGER     OUTPUT   return status
C
C COMMON BLOCKS: N/A
C
C FILES: None
C
C DATA BASES: ISIS LLT_DB
C     Name          Table      Usage        Description
C   ----------   ------------- ---------  -------------------------
C  sfc_ship      SFC_SHIP      IN         surface ship obs
C
C NON-FILE INPUT/OUTPUT: N/A
C
C ERROR CONDITIONS:
C      CONDITION              ACTION
C   -----------------      ----------------------------
C  DTG error                 Print err message & return
C  Error return from LRD     Print err message
C  Error return from LCLOS   Print err message
C
C ADDITIONAL COMMENTS:  NONE
C
C....................MAINTENANCE SECTION...............................
C
C MODULES CALLED:
C       Name        Description
C      -------   ----------------------
C      LCLOS      ISIS LLT close
C      LEN_TRIM   Determines the length of a string
C      LRD        ISIS LLT read
C      TRIM       Removes the trailing blanks
C
C LOCAL VARIABLES AND        Structures are documented in detail
C         STRUCTURES:      where they are defined in the code
C                      within include files.
C
C METHOD:
C    Set seq_type to 'sfc_ship'
C    See raob_qc_read for the rest.
C
C INCLUDE FILES:
C     Name                   Description
C   ---------------   ------------------------------------------------
C   SFC_SHIP.H        surface ship header file
C   V_DATA.H          common variables for verobs
C
C COMPILER DEPENDENCIES:  f90
```

```
C
C  COMPILE OPTIONS:  -f fixed -c
C
C  MAKEFILE:  Located at /a/ops/app/mverif/src/sub/makeverobslib
C          UNICOS make
C
C  RECORD OF CHANGES:
C
C  <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
C     Initial submission
C
C..............................END PROLOGUE............................
C
      implicit none
      include 'v_data.h'
      include 'SFC_SHIP.H'

c**********************************************************************
c     formal parameters
c**********************************************************************
      character(8),  intent(in) :: vrsnnam
      character(24), intent(in) :: dsetnm
      character(8),  intent(in) :: seclvl
      character(10), intent(in) :: dtg
      character(32), intent(in) :: param
      real,          intent(in) :: lvl
      real,          intent(in) :: minlat
      real,          intent(in) :: maxlat
      real,          intent(in) :: minlon
      real,          intent(in) :: maxlon
      real                      :: lat(size)
      real                      :: lon(size)
      integer                   :: nobs
      real                      :: obs(size)
      integer                   :: istat

c**********************************************************************
c     local variables used as arguments for LRD:
c**********************************************************************
      character(24) :: seq_type
      real          :: hr
      CHARACTER(16) :: MINDTG     ! Minmum date and time group to read.
      CHARACTER(16) :: MAXDTG     ! Maximum date and time group to read.
      REAL          :: MINHR      ! Minmum hour to read.
      REAL          :: MAXHR      ! Maximum hour to read.
      CHARACTER(16) :: RSN_IN     ! Reporting source name.
      REAL          :: FCST_IN    ! Desired forecast "TAU".
      CHARACTER(24) :: MINUPTM    ! Minimum update time.
      CHARACTER(56) :: REMARKS    ! Description of data/assoc. record.
      CHARACTER(16) :: RPT_DTG    ! Actual date & time group for report.
      REAL          :: RPT_HR     ! Reported hour read.
      REAL          :: RPT_LAT    ! Reported latitude read.
      REAL          :: RPT_LON    ! Reported longitude read.
      CHARACTER(16) :: RPT_RSN    ! Reported longitude read.
      REAL          :: RPT_FCST   ! Reported "TAU" or forecast time.
      CHARACTER(24) :: RPT_CRETM  ! Record creation date.
      CHARACTER(24) :: RPT_UDT    ! Report's last update time.
      INTEGER       :: BUFFLAG    ! 0 => Input is in FBUFF
                                  ! 1 => Input is in IBUFF
      INTEGER       :: LLT_ID     ! Unique database LLT identifier for each
                                  ! dataset.
      INTEGER       :: BLKSEQID   ! Unique database LLT block identifier.
      INTEGER       :: RECSEQID   ! Unique database LLT record identifier.

      TYPE(sfc_ship_int):: IBUFF  ! integer record structure.
      TYPE(sfc_ship):: FBUFF      ! Real record structure.

c*********************************************************************
c   Arguments for  LCLOS  (that get "*" for values).
c*********************************************************************
      CHARACTER(24) :: SEQTYPE_X  ! Report type.
      CHARACTER(8)  :: VRSNNAM_X  ! Version of ISIS software used.
      CHARACTER(24) :: DSETNAM_X  ! Data set name used.
      CHARACTER(8)  :: SECLVL_X   ! 7 character security
                                  ! classification level.
      CHARACTER(16) :: DTG_X      ! Date Time Group for write.

c*********************************************************************
c   Other local variables
c*********************************************************************
      integer :: levels
      integer :: status, i, status2

      seq_type = 'sfc_ship' ! Report type
      istat = 0

!*********************************************************************
!   Set up date and time group in YYYYMMDDHH format in DTG.
!*********************************************************************
      IF ( LEN_TRIM(DTG) == 10 ) THEN
        READ (UNIT=DTG(9:10),FMT='(F2.0)',IOSTAT=STATUS) HR
        IF ( STATUS == 0 ) THEN
          IF ( HR < 12. ) THEN
            HR = 0.
          ELSE
            HR = 12.
          END IF
        ELSE
          WRITE *, ' Cannot read hour "', DTG(9:10),
     2            ' from date & time group ', TRIM(DTG)
          istat = -1
          RETURN
        END IF
      ELSE
      STATUS = 10
      WRITE *, 'sfcship: Got date and time group ',
   2          TRIM(DTG), ' of length ',
   3          LEN_TRIM(DTG), ' but expected length == 10.'
      istat = -1
      RETURN
    END IF

!***********************************************************************
!   Set the input parameters used to get a read-back value.
!***********************************************************************
    MINDTG  = DTG;     MAXDTG  = DTG
    MINHR   = HR;      MAXHR   = HR+11.999
    RSN_IN  = '*'
    FCST_IN  = 0.0    ! Report forecast period or Tau (normal = 0.0)
    MINUPTM  = '*'
    BUFFLAG = 0      !  Want (both) floating (and integer).

!***********************************************************************
!   get the data from LLT db
!***********************************************************************
    I = 0
    nobs = 0

    DO WHILE ( STATUS == 0 )
      CALL LRD(seq_type, vrsnnam, dsetnm,    SECLVL,
   2         MINDTG,  MINHR,   MAXDTG,    MAXHR,
   3         MINLAT,  MAXLAT,  MINLON,    MAXLON,
   4         RSN_IN,  FCST_IN,  MINUPTM,   BUFFLAG,
   5         RPT_DTG,  RPT_HR,   RPT_LAT,   RPT_LON,
   6         RPT_RSN,  RPT_FCST,  RPT_CRETM, RPT_UDT,
   7         LLT_ID,   BLKSEQID,  RECSEQID,
   8         IBUFF,   FBUFF,    STATUS )
      IF ( STATUS /= 0 ) THEN
        IF ( STATUS /= 100 ) THEN
          ! Ignore normal no-more-data return code
          WRITE *, ' Read from ISIS failed.  Code = ', STATUS, '.'
          istat = status
        END IF
      ELSE  ! successful LRD
        I = I + 1

c***************************************************************************
c       pick out the relevant info and fill the array
c       we want to use the qc flag to discard the bad obs when available
c***************************************************************************

        if (param == 'air_temp') then
          if (fbuff % air_temp < check_val) then
            nobs = nobs + 1
            lat(nobs) = fbuff % crse_lat
            lon(nobs) = fbuff % crse_lon
```

```
              obs(nobs) = fbuff % air_temp
            end if

          else if (param == 'sea_lvl_pres') then
            if (fbuff % sea_lvl_pres < check_val) then
              nobs = nobs + 1
              lat(nobs) = fbuff % crse_lat
              lon(nobs) = fbuff % crse_lon
              obs(nobs) = (fbuff % sea_lvl_pres) / 100.0
            end if

          else if (param == 'sea_temp') then
            !check pos_qc_id for position error first
            if (fbuff % pos_qc_id == 0 .or.
     2          fbuff % pos_qc_id == 1) then
              !sea_temp_qc flag of 0 or 1 is the only obs we want to use
              if ( (fbuff % sea_temp_qc_id == 1 .or.
     2              fbuff % sea_temp_qc_id == 0) .or.
     3             (fbuff % sea_temp < check_val) ) then
                nobs = nobs + 1
                lat(nobs) = fbuff % crse_lat
                lon(nobs) = fbuff % crse_lon
                obs(nobs) = fbuff % sea_temp
              end if
            end if

          !for inst_wav_per (grid parm 'peak_wav_per')
          else if (param == 'inst_wav_per') then
            if (fbuff % inst_wav_per < check_val) then
              nobs = nobs + 1
              lat(nobs) = fbuff % crse_lat
              lon(nobs) = fbuff % crse_lon
              obs(nobs) = fbuff % inst_wav_per
            end if

          !for inst_wav_ht_2 (grid parm 'sig_wav_ht')
          else if (param == 'inst_wav_ht_2') then
            if (fbuff % inst_wav_ht_2 < check_val) then
              nobs = nobs + 1
              lat(nobs) = fbuff % crse_lat
              lon(nobs) = fbuff % crse_lon
              obs(nobs) = fbuff % inst_wav_ht_2
            end if

          else if (param == 'wnd_dir') then
            if (fbuff % wnd_dir < check_val) then
              nobs = nobs + 1
              lat(nobs) = fbuff % crse_lat
              lon(nobs) = fbuff % crse_lon
              obs(nobs) = fbuff % wnd_dir
            end if
          else if (param == 'wnd_spd') then
            if (fbuff % wnd_spd < check_val) then
              nobs = nobs + 1
              lat(nobs) = fbuff % crse_lat
              lon(nobs) = fbuff % crse_lon
              obs(nobs) = fbuff % wnd_spd
            end if

          end if ! param
        end if  ! OK status
      END DO    ! i loop

      IF ( STATUS == 100 )  STATUS = 0
      write *, ' '
      WRITE *, ' Called LRD ', I, ' times.'
      write *, ' Read ', nobs, ' obs of sequence type ', TRIM(SEQ_TYPE),
     2       '.'

!*************************************************************************
!   Close the dataset (now open for reading) again.
!*************************************************************************
      SEQTYPE_X = '*' ;  VRSNNAM_X = '*' ;  DSETNAM_X = '*'
      SECLVL_X  = '*' ;  DTG_X     = '*'

      CALL LCLOS(SEQTYPE_X, VRSNNAM_X, DSETNAM_X,
     2        SECLVL_X, DTG_X, STATUS2)
      IF ( STATUS2 /= 0 ) THEN
        WRITE *, ' Could not close ISIS table. ',
     2         ' Error code is ', STATUS2, '.'
      END IF

      return
      end subroutine sfc_ship_read
```

14. ssmetqc.f90

```
      subroutine sfc_ship_met_qc_read(vrsnnam, dsetnm, seclvl, dtg,
     2                      param,  lvl,   minlat, maxlat,
     3                      minlon,  maxlon, lat,    lon,
     4                      nobs,    obs,    istat)
C
C............................START PROLOGUE............................
C
C  SCCS IDENTIFICATION:  @(#)ssmetqc.f90 1.1 04/24/98 /h/cm/library/mverif/src/sub/ssmetqc.f90_v
C
C  CONFIGURATION IDENTIFICATION:   NONE
C
C  MODULE NAME:  sfc_ship_met_qc_read
C
C  DESCRIPTION:  subroutine to read the sfc_ship_met_qc data and pick
C              out the obs data for the given parameter
```

```
C
C COPYRIGHT:            (c) 1996 FLENUMMETOCCEN
C                      U.S. GOVERNMENT DOMAIN
C                      ALL RIGHTS RESERVED
C
C CONTRACT NUMBER AND TITLE:  N/A
C
C REFERENCES: NONE
C
C CLASSIFICATION:  Unclassified
C
C RESTRICTIONS:  NONE
C
C COMPUTER/OPERATING SYSTEM
C          DEPENDENCIES:  Cray UNICOS
C
C LIBRARIES OF RESIDENCE:  /a/ops/bin
C
C USAGE:
C   call sfc_ship_met_qc_read(vrsnnam, dsetnm, seclvl, dtg,
C                      param,  lvl,   minlat, maxlat,
c                      minlon,  maxlon, lat,   lon,
C                      nobs,   obs,   istat)
C
C PARAMETERS:
C    Name         Type       Usage        Description
C  ----------   ----------   -------  ----------------------------
C  VRSNNAM      CHAR*8       INPUT    llt version name
C  DSETNM       CHAR*24      INPUT    data set name
C  SECLVL       CHAR*8       INPUT    classification
C  DTG          CHAR*10      INPUT    date time group for read
C  PARAM        CHAR*32      INPUT    parameter
C  LVL          REAL         INPUT    level type
C  MINLAT       REAL         INPUT    minimum latitude
C  MAXLAT       REAL         INPUT    maximum latitude
C  MINLON       REAL         INPUT    minimum longitude
C  MAXLON       REAL         INPUT    maximum longitude
C  LAT          REAL(size)   OUTPUT   obs latitude
C  LON          REAL(size)   OUTPUT   obs longitude
C  NOBS         INTEGER      OUTPUT   number of obs
C  OBS          REAL(size)   OUTPUT   obs value
C  ISTAT        INTEGER      OUTPUT   return status
C
C COMMON BLOCKS: N/A
C
C FILES: None
C
C DATA BASES: ISIS LLT_DB
C    Name          Table        Usage       Description
C  ----------   -------------- ---------  -------------------------
C  sfc_ship_met_qc SFC_SHIP_MET_QC   IN       surface ship met qc obs
C
```

```
C NON-FILE INPUT/OUTPUT: N/A
C
C ERROR CONDITIONS:
C      CONDITION              ACTION
C   -----------------       ---------------------------
C  DTG error                 Print err message & return
C  Error return from LRD     Print err message
C  Error return from LCLOS   Print err message
C
C ADDITIONAL COMMENTS:  NONE
C
C....................MAINTENANCE SECTION................................
C
C MODULES CALLED:
C       Name          Description
C       -------    ----------------------
C      LCLOS       ISIS LLT close
C      LEN_TRIM   Determines the length of a string
C      LRD         ISIS LLT read
C      TRIM        Removes the trailing blanks
C
C LOCAL VARIABLES AND        Structures are documented in detail
C        STRUCTURES:        where they are defined in the code
C                           within include files.
C
C METHOD:
C    Set seq_type to 'sfc_ship_met_qc'
C    See raob_qc_read for the rest.
C
C INCLUDE FILES:
C     Name                      Description
C   ---------------   ------------------------------------------------
C   SFC_SHIP_MET_QC.H  surface ship header file
C   V_DATA.H          common variables for verobs
C
C COMPILER DEPENDENCIES:  f90
C
C COMPILE OPTIONS:  -f fixed -c
C
C MAKEFILE:   Located at /a/ops/app/mverif/src/sub/makeverobslib
C          UNICOS make
C
C RECORD OF CHANGES:
C
C <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
C     Initial submission
C
C...............................END PROLOGUE.............................
C
      implicit none
      include 'v_data.h'
      include 'SFC_SHIP_MET_QC.H'
```

```
c***********************************************************************
c    formal parameters
c***********************************************************************
     character(8),  intent(in) :: vrsnnam
     character(24), intent(in) :: dsetnm
     character(8),  intent(in) :: seclvl
     character(10), intent(in) :: dtg
     character(32), intent(in) :: param
     real,          intent(in) :: lvl
     real,          intent(in) :: minlat
     real,          intent(in) :: maxlat
     real,          intent(in) :: minlon
     real,          intent(in) :: maxlon
     real                      :: lat(size)
     real                      :: lon(size)
     integer                    :: nobs
     real                      :: obs(size)
     integer                    :: istat

c***********************************************************************
c    local variables used as arguments for LRD:
c***********************************************************************
     character(24) :: seq_type
     real          :: hr
     CHARACTER(16) :: MINDTG     ! Minmum date and time group to read.
     CHARACTER(16) :: MAXDTG     ! Maximum date and time group to read.
     REAL          :: MINHR      ! Minmum hour to read.
     REAL          :: MAXHR      ! Maximum hour to read.
     CHARACTER(16) :: RSN_IN     ! Reporting source name.
     REAL          :: FCST_IN    ! Desired forecast "TAU".
     CHARACTER(24) :: MINUPTM    ! Minimum update time.
     CHARACTER(56) :: REMARKS    ! Description of data/assoc. record.
     CHARACTER(16) :: RPT_DTG    ! Actual date & time group for report.
     REAL          :: RPT_HR     ! Reported hour read.
     REAL          :: RPT_LAT    ! Reported latitude read.
     REAL          :: RPT_LON    ! Reported longitude read.
     CHARACTER(16) :: RPT_RSN    ! Reported longitude read.
     REAL          :: RPT_FCST   ! Reported "TAU" or forecast time.
     CHARACTER(24) :: RPT_CRETM  ! Record creation date.
     CHARACTER(24) :: RPT_UDT    ! Report's last update time.
     INTEGER       :: BUFFLAG    ! 0 => Input is in FBUFF
                                 ! 1 => Input is in IBUFF
     INTEGER       :: LLT_ID     ! Unique database LLT identifier for each
                                 ! dataset.
     INTEGER       :: BLKSEQID   ! Unique database LLT block identifier.
     INTEGER       :: RECSEQID   ! Unique database LLT record identifier.

     TYPE(sfc_ship_met_qc_int) :: IBUFF
     TYPE(sfc_ship_met_qc) :: FBUFF ! Real record structure.

c***********************************************************************
c    Arguments for  LCLOS  (that get "*" for values).
```

```
c*********************************************************************
   CHARACTER(24) :: SEQTYPE_X  ! Report type.
   CHARACTER(8)  :: VRSNNAM_X  ! Version of ISIS software used.
   CHARACTER(24) :: DSETNAM_X  ! Data set name used.
   CHARACTER(8)  :: SECLVL_X   ! 7 character security
                    ! classification level.
   CHARACTER(16) :: DTG_X      ! Date Time Group for write.

c*********************************************************************
c   Other local variables
c*********************************************************************
   integer :: levels
   integer :: status, i, status2

   seq_type = 'sfc_ship_met_qc' ! Report type
   istat = 0

!*********************************************************************
!   Set up date and time group in YYYYMMDDHH format in DTG.
!*********************************************************************
   IF ( LEN_TRIM(DTG) == 10 ) THEN
     READ (UNIT=DTG(9:10),FMT='(F2.0)',IOSTAT=STATUS) HR
     IF ( STATUS == 0 ) THEN
       IF ( HR < 12. ) THEN
         HR = 0.
       ELSE
         HR = 12.
       END IF
     ELSE
       WRITE *, ' Cannot read hour "', DTG(9:10),
   2         ' from date & time group ', TRIM(DTG)
       istat = -1
       RETURN
     END IF
   ELSE
     STATUS = 10
     WRITE *, 'ssmetqc: Got date and time group ',
   2        TRIM(DTG), ' of length ',
   3        LEN_TRIM(DTG), ' but expected length == 10.'
     istat = -1
     RETURN
   END IF

!*********************************************************************
!   Set the input parameters used to get a read-back value.
!*********************************************************************
   MINDTG  = DTG;    MAXDTG  = DTG
   MINHR   = HR;     MAXHR   = HR+11.999
   RSN_IN  = '*'
   FCST_IN  = 0.0   ! Report forecast period or Tau (normal = 0.0)
   MINUPTM  = '*'
   BUFFLAG = 0     ! Want (both) floating (and integer).
```

```
!*********************************************************************
!   get the data from LLT db
!*********************************************************************
    I = 0
    nobs = 0

    DO WHILE ( STATUS == 0 )
      CALL LRD(seq_type, vrsnnam,  dsetnm,    SECLVL,
    2        MINDTG,  MINHR,    MAXDTG,    MAXHR,
    3        MINLAT,  MAXLAT,   MINLON,    MAXLON,
    4        RSN_IN,  FCST_IN,  MINUPTM,   BUFFLAG,
    5        RPT_DTG,  RPT_HR,   RPT_LAT,   RPT_LON,
    6        RPT_RSN,  RPT_FCST, RPT_CRETM, RPT_UDT,
    7        LLT_ID,  BLKSEQID, RECSEQID,
    8        IBUFF,   FBUFF,    STATUS )
      IF ( STATUS /= 0 ) THEN
        IF ( STATUS /= 100 ) THEN
          ! Ignore normal no-more-data return code
          WRITE *, ' Read from ISIS failed.  Code = ', STATUS, '.'
          istat = status
        END IF
      ELSE  ! successful LRD
        I = I + 1

c*************************************************************************
c        pick out the relevant info and fill the array
c        we want to use the qc flag to discard the bad obs
c*************************************************************************
        if (param == 'air_temp') then
          if (fbuff % air_temp < check_val .and.
    2        fbuff % air_temp_qc_id == 1) then
            nobs = nobs + 1
            lat(nobs) = fbuff % crse_lat
            lon(nobs) = fbuff % crse_lon
            obs(nobs) = fbuff % air_temp
          end if

        else if (param == 'sea_lvl_pres') then
          if (fbuff % sea_lvl_pres < check_val .and.
    2        fbuff % sea_lvl_pres_qc_id == 1) then
            nobs = nobs + 1
            lat(nobs) = fbuff % crse_lat
            lon(nobs) = fbuff % crse_lon
            obs(nobs) = (fbuff % sea_lvl_pres) / 100.0
          end if

        else if (param == 'sea_temp') then
          if (fbuff % sea_temp < check_val .and.
    2        fbuff % sea_temp_qc_id == 1) then
            nobs = nobs + 1
            lat(nobs) = fbuff % crse_lat
            lon(nobs) = fbuff % crse_lon
```

```
              obs(nobs) = fbuff % sea_temp
            end if

          else if (param == 'wnd_dir') then
            if (fbuff % wnd_dir < check_val .and.
     2          fbuff % wnd_qc_id == 1) then
              nobs = nobs + 1
              lat(nobs) = fbuff % crse_lat
              lon(nobs) = fbuff % crse_lon
              obs(nobs) = fbuff % wnd_dir
            end if

          else if (param == 'wnd_spd') then
            if (fbuff % wnd_spd < check_val .and.
     2          fbuff % wnd_qc_id ==1) then
              nobs = nobs + 1
              lat(nobs) = fbuff % crse_lat
              lon(nobs) = fbuff % crse_lon
              obs(nobs) = fbuff % wnd_spd
            end if

          end if ! param
        end if   ! OK status
      END DO     ! i loop

      IF ( STATUS == 100 )  STATUS = 0
      write *, ' '
      WRITE *, ' Called LRD ', I, ' times.'
      write *, ' Read ', nobs, ' obs of sequence type ', TRIM(SEQ_TYPE),
     2        '.'

!*************************************************************************
!    Close the dataset (now open for reading) again.
!*************************************************************************
      SEQTYPE_X = '*' ;  VRSNNAM_X = '*' ;  DSETNAM_X = '*'
      SECLVL_X  = '*' ;  DTG_X     = '*'

      CALL LCLOS(SEQTYPE_X, VRSNNAM_X, DSETNAM_X,
     2         SECLVL_X, DTG_X, STATUS2)
      IF ( STATUS2 /= 0 ) THEN
        WRITE *, ' Could not close ISIS table. ',
     2         ' Error code is ', STATUS2, '.'
      END IF

      return
      end subroutine sfc_ship_met_qc_read
```

B. STAT LIB

1. Compute_bias module

```
   SUBROUTINE COMPUTE_BIAS (array1, array2,
  2                  arr_size, geomname, bias)
C
C.............................START PROLOGUE............................
C
C SCCS IDENTIFICATION: @(#)find-bias.f90 1.1 04/24/98 /h/cm/library/mverif/src/sub/find-bias.f90_v
C
C  CONFIGURATION IDENTIFICATION:   NONE
C
C  MODULE NAME:  compute_bias
C
C  DESCRIPTION:  subroutine to compute the bias (mean error)
C
C  COPYRIGHT:              (c) 1998 FLENUMMETOCCEN
C                    U.S. GOVERNMENT DOMAIN
C                    ALL RIGHTS RESERVED
C
C  CONTRACT NUMBER AND TITLE:   N/A
C
C  CLASSIFICATION:   Unclassified
C
C  RESTRICTIONS:   NONE
C
C  COMPUTER/OPERATING SYSTEM
C           DEPENDENCIES:  Cray UNICOS
C
C  LIBRARIES OF RESIDENCE:   /a/ops/bin
C
C  USAGE:
C    call compute_bias( array1, array2, arr_size, geomname, bias)
C
C  PARAMETERS:
C     Name          Type        Usage          Description
C   ----------    ----------    -------  ----------------------------
C   array1        REAL(360*181)  INPUT    first array
C   array2        REAL(360*181)  INPUT    second array
C   arr_size       INTEGER       INPUT    array size
C   geomname       CHAR*32       INPUT    geometry name
C   bias          REAL          OUTPUT   computed bias
C
C  COMMON BLOCKS: N/A
C
C  FILES: None
C
C  ERROR CONDITIONS:
C       CONDITION              ACTION
```

```
C   -----------------     ----------------------------
C
C ADDITIONAL COMMENTS:  NONE
C
C..................MAINTENANCE SECTION...............................
C
C MODULES CALLED:
C      Name        Description
C      -------   ----------------------
C      FIND_MAP_FACT determine the map factor for the geometry
C
C LOCAL VARIABLES AND        Structures are documented in detail
C       STRUCTURES:       where they are defined in the code
C                    within include files.
C METHOD:
C
C INCLUDE FILES: NONE
C
C COMPILER DEPENDENCIES:  f90
C
C COMPILE OPTIONS:  -f fixed -c
C
C MAKEFILE:  Located at /a/ops/app/mverif/src/sub/makestatlib
C          UNICOS make
C
C RECORD OF CHANGES:
C
C <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
C    Initial submission
C
C.............................END PROLOGUE............................
C
      !***********************************************************
      ! formula used:
      ! (array1 - array2) / arr_size
      ! [(array1 - array2) * xmap_factor * ymap_factor]
      ! / [4*pi*a_square]
      !***********************************************************
      implicit none

      integer:: im, jm, imjm
      parameter(im = 360)
      parameter(jm = 181)
      parameter(imjm = im * jm)

      !***********************************************************
      !formal parameter
      !***********************************************************
      real, intent(in)        :: array1(imjm)
      real, intent(in)        :: array2(imjm)
      integer, intent(in)      :: arr_size
      character(32)           :: geomname
      real                   :: bias

      !***********************************************************
      !local var
      !***********************************************************
      integer :: i
      integer :: lengeom
      real    :: sum, dif, sumx
      real    :: xmap_factor(imjm), ymap_factor(imjm)
      real    :: pi, a_square
      integer strlen

      pi = 2.0 * asin(1.0)
      a_square = (6.375e+06) ** 2
      sum = 0.
      dif = 0.

      if (geomname(1:4) /= 'NONE') then
        write *, "calling find-map-factor from find-bias for ",
     2     geomname
        CALL FIND_MAP_FACTOR(geomname, xmap_factor, ymap_factor)
        do i = 1, arr_size
          dif = (array1(i) - array2(i))
     2         * xmap_factor(i) * ymap_factor(i)
          sum = sum + dif
        end do
        bias = sum / (4*pi*a_square)
      else
        do i = 1, arr_size
          dif = array1(i) - array2(i)
          sum = sum + dif
        end do
        bias = sum / arr_size
      end if

      return
      END SUBROUTINE COMPUTE_BIAS
```

2. Compute_rms

```
      SUBROUTINE COMPUTE_RMS (array1, array2,
     2                 arr_size, geomname, rms)
C
C..............................START PROLOGUE............................
C
C  SCCS IDENTIFICATION:  @(#)find-rms.f90 1.1 04/24/98 /h/cm/library/mverif/src/sub/find-rms.f90_v
C
C  CONFIGURATION IDENTIFICATION:   NONE
C
C  MODULE NAME:  compute_rms
C
```

```
C DESCRIPTION:  subroutine to compute the rms
C
C COPYRIGHT:              (c) 1998 FLENUMMETOCCEN
C                   U.S. GOVERNMENT DOMAIN
C                   ALL RIGHTS RESERVED
C
C CONTRACT NUMBER AND TITLE:   N/A
C
C CLASSIFICATION:  Unclassified
C
C RESTRICTIONS:  NONE
C
C COMPUTER/OPERATING SYSTEM
C          DEPENDENCIES:  Cray UNICOS
C
C LIBRARIES OF RESIDENCE:  /a/ops/bin
C
C USAGE:
C   call compute_rms( array1, array2, arr_size, geomname, rms)
C
C PARAMETERS:
C     Name         Type        Usage         Description
C   ----------     ----------    -------  ----------------------------
C   array1       REAL(360*181)  INPUT    first array
C   array2       REAL(360*181)  INPUT    second array
C   arr_size      INTEGER       INPUT    array size
C   geomname      CHAR*32       INPUT    geometry name
C   rms          REAL          OUTPUT   computed rms
C
C COMMON BLOCKS: N/A
C
C FILES: None
C
C ERROR CONDITIONS:
C      CONDITION              ACTION
C   -----------------      ----------------------------
C
C ADDITIONAL COMMENTS:  NONE
C
C...................MAINTENANCE SECTION................................
C
C MODULES CALLED:
C   Name         Description
C   -------     ----------------------
C FIND_MAP_FACT determine the map factor for the geometry
C
C LOCAL VARIABLES AND         Structures are documented in detail
C        STRUCTURES:       where they are defined in the code
C                       within include files.
C METHOD:
C
C INCLUDE FILES: NONE
```

```
C
C  COMPILER DEPENDENCIES:  f90
C
C  COMPILE OPTIONS:  -f fixed -c
C
C  MAKEFILE:  Located at /a/ops/app/mverif/src/sub/makestatlib
C             UNICOS make
C
C  RECORD OF CHANGES:
C
C  <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
C     Initial submission
C
C..............................END PROLOGUE.............................
C
      !*******************************************************
      !sqrt[(array1-array2)**2/arr_size]
      !sqrt[(array1-array2)**2*xmap_factor*ymap_factor]
      !   / [4*pi*a_square]
      !*******************************************************
      implicit none

      integer:: im, jm, imjm
      parameter(im = 360)
      parameter(jm = 181)
      parameter(imjm = im * jm)

      !*******************************************************
      !formal parameters
      !*******************************************************
      real,          intent(in) :: array1(imjm)
      real,          intent(in) :: array2(imjm)
      integer,       intent(in) :: arr_size
      character(32), intent(in) :: geomname
      real                      :: rms

      !*******************************************************
      !local var
      !*******************************************************
      integer :: i
      real    :: xmap_factor(imjm), ymap_factor(imjm)
      real    :: sum, dif, sumx, difx
      real    :: pi, a_square

      pi = 2.0 * asin(1.0)
      a_square = (6.375e+06) ** 2
      difx = 0.
      sumx = 0.

      if (geomname(1:4) /= 'NONE') then
        CALL FIND_MAP_FACTOR(geomname, xmap_factor, ymap_factor)
        do i = 1, arr_size
      difx = (array1(i) - array2(i))**2
  2        * xmap_factor(i) * ymap_factor(i)
      sumx = sumx + difx
    end do
    rms = sqrt(sumx) / (4*pi*a_square)
  else
    do i = 1, arr_size
      difx = (array1(i) - array2(i))**2
      sumx = sumx + difx
    end do
    rms = sqrt(sumx / arr_size)
  end if

  return
  END SUBROUTINE COMPUTE_RMS
```

3. Compute_std

```
  SUBROUTINE COMPUTE_STD (array1, array2,
  2                 arr_size, geomname, std)
C
C.............................START PROLOGUE............................
C
C  SCCS IDENTIFICATION:  @(#)find-std.f90 1.1 04/24/98 /h/cm/library/mverif/src/sub/find-std.f90_v
C
C  CONFIGURATION IDENTIFICATION:   NONE
C
C  MODULE NAME:  compute_std
C
C  DESCRIPTION:  subroutine to compute the std
C
C  COPYRIGHT:             (c) 1998 FLENUMMETOCCEN
C                   U.S. GOVERNMENT DOMAIN
C                   ALL RIGHTS RESERVED
C
C  CONTRACT NUMBER AND TITLE:  N/A
C
C  CLASSIFICATION:  Unclassified
C
C  RESTRICTIONS:  NONE
CC  COMPUTER/OPERATING SYSTEM
C          DEPENDENCIES:  Cray UNICOS
C
C  LIBRARIES OF RESIDENCE:   /a/ops/bin
C
C  USAGE:
C   call compute_std( array1, array2, arr_size, geomname, std)
C
C  PARAMETERS:
C     Name         Type       Usage         Description
C   ----------    ----------    -------  ---------------------------
```

```
C  array1       REAL(360*181)  INPUT   first array
C  array2       REAL(360*181)  INPUT   second array
C  arr_size      INTEGER       INPUT   array size
C  geomname      CHAR*32       INPUT   geometry name
C  std          REAL          OUTPUT  computed std
C
C  COMMON BLOCKS: N/A
C
C  FILES: None
C
C  ERROR CONDITIONS:
C       CONDITION            ACTION
C    -----------------      ----------------------------
C
C  ADDITIONAL COMMENTS:  NONE
C
C....................MAINTENANCE SECTION................................
C
C  MODULES CALLED:
C     Name        Description
C    -------    ----------------------
C   FIND_MAP_FACT determine the map factor for the geometry
C
C  LOCAL VARIABLES AND       Structures are documented in detail
C         STRUCTURES:      where they are defined in the code
C                        within include files.
C  METHOD:
C
C  INCLUDE FILES: NONE
C
C  COMPILER DEPENDENCIES:  f90
C
C  COMPILE OPTIONS:  -f fixed -c
C
C  MAKEFILE:  Located at /a/ops/app/mverif/src/sub/makestatlib
C           UNICOS make
C
C  RECORD OF CHANGES:
C
C  <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
C     Initial submission
C
C..............................END PROLOGUE.............................
C
     !*********************************************************
     !sqrt[{(array1-array2)**2/arr_size} -
     !    {((array1-array2)/arr_size)**2}]
     !sqrt[{(array1-array2)**2*xmap_factor*ymap_factor}
     !   -{((array1-array2)*xmap_factor*ymap_factor)**2}]
     !   / [4*pi*a_square]
     !*********************************************************
     implicit none
```

```
      integer:: im, jm, imjm
      parameter(im = 360)
      parameter(jm = 181)
      parameter(imjm = im * jm)

      !********************************************************
      !formal parameter
      !********************************************************
      real, intent(in)        :: array1(imjm)
      real, intent(in)        :: array2(imjm)
      integer, intent(in)     :: arr_size
      character(32), intent(in) :: geomname
      real                    :: std

      !********************************************************
      !local var
      !********************************************************
      integer :: i
      real    :: xmap_factor(imjm), ymap_factor(imjm)
      real    :: sum, dif, sumx, difx
      real    :: pi, a_square

      pi = 2.0 * asin(1.0)
      a_square = (6.375e+06) ** 2
      sum = 0.
      dif = 0.
      difx = 0.
      sumx = 0.

      if (geomname(1:4) /= 'NONE') then
        CALL FIND_MAP_FACTOR(geomname, xmap_factor, ymap_factor)
        do i = 1, arr_size
          dif = (array1(i) - array2(i))
     2        * xmap_factor(i) * ymap_factor(i)
          difx = (array1(i) - array2(i))**2
     2        * xmap_factor(i) * ymap_factor(i)
          sum = sum + dif
          sumx = sumx + difx
        end do
        std = sqrt(sumx / 4*pi*a_square - (sum / (4*pi*a_square))**2)
      else

        do i = 1, arr_size
          dif = array1(i) - array2(i)
          sum = sum + dif
          difx = (array1(i) - array2(i))**2
          sumx = sumx + difx
        end do
        std = sqrt(sumx/arr_size - (sum/arr_size)**2)
      end if

      return
```

```
END SUBROUTINE COMPUTE_STD
```

C. GRAPHICS

1. Plot_data.pro

```
pro plot_data

  ;************************************************************
  ; setup color chart
  ;************************************************************
  COMMON colors,  r_orig, g_orig, b_orig, r_curr, g_curr, b_curr
  maxcol = !D.N_COLORS
  r_curr = bindgen(maxcol)
  g_curr = r_curr
  b_curr = r_curr

  ;       wht,grn,gry,wht,tur,blu,ylw,pur,blk,red
  r_curr = [255,  0,211,255,  0,  0,255, 55,  0,255]
  g_curr = [255,100,211,255,200,  0,255,  0,  0,  0]
  b_curr = [255,  0,211,255,230,255,  0, 55,  0,  0]

  ;******************************************************
  ; to graph on the screen, must have the DISPLAY env set
  ;******************************************************
  ;TVLCT, r_curr, g_curr, b_curr

  ;integers
  nColors = 0
  nHeader = 0
  nRecords = 0
  nmatch = 0
  fcstPer = 0

  ;floats
  sng = 0.0
  level1 = 0.0
  minrange = 0.0
  maxrange = 0.0

  ;strings
  filename = "
  str = "
  strFormat = "
  strHeader = "
  strLegend = "
  param = "
  obType = "
  geomName = "
```

```
modelName = ''
name = ''
yname = ''

;structures
datLine = {dat, v_dtg:' ', nobs:0, parm:' ', units:' ', $
           geom:' ', typlvl:' ', lvl_1:0.0, tau:0, $
           typstat:' ', stat_val:0.0, v_src:' ', obs_type:' '}

strFmt = '(a10, 2x, i5, a20, a15, a30, a15, f8.2, i5, a15, f8.2, a10, a25)'

;****************************************************
; get the env vars and data filename
;****************************************************
param = GETENV('PARM_NAME')
level1 = GETENV('LVL_1')
fcstPer = GETENV('FCSTPER')
obType = GETENV('OBSTYPE')
geomName = GETENV('GEOM_NAME')
modelName = GETENV('MODEL')
filename = GETENV('FILENAME')

; determine the number of records in the data file
data=READ_ASCII(fileName, count=nRecords)
print, "record count = ", nRecords

;array declarations
fields = replicate(datLine, nRecords)
bias = replicate(datLine, nRecords)
std = replicate(datLine, nRecords)
rms = replicate(datLine, nRecords)
std1 = FLTARR(nRecords)
std2 = FLTARR(nRecords)
strDTG = STRARR(nRecords)
lonDTG = FLTARR(nRecords, /NOZERO)
numObs = INTARR(nRecords)

openr, 10, filename

for n=0, nRecords-1 do begin
  READF, 10, datLine, FORMAT=strFmt
  fields[n] = datLine
endfor

close, 10

fields = fields(SORT(fields[*].v_dtg))

;****************************************************
; get the sub arrays
;****************************************************
bias = fields[WHERE((STRTRIM(fields[*].parm) EQ param) and $
             (fields[*].lvl_1 EQ level1) and $
             (STRTRIM(fields[*].geom) EQ geomName) and $
             (fields[*].tau EQ fcstPer) and $
             (STRTRIM(fields[*].obs_type) EQ obType) and $
             (STRTRIM(fields[*].typstat) EQ 'bias'), nmatch)]
start_date = JULDAY(STRMID(bias[0].v_dtg,4,2), $
             STRMID(bias[0].v_dtg,6,2), $
             STRMID(bias[0].v_dtg,0,4))
end_date = JULDAY(STRMID(bias[nmatch-1].v_dtg,4,2), $
            STRMID(bias[nmatch-1].v_dtg,6,2), $
            STRMID(bias[nmatch-1].v_dtg,0,4))
start_time = FIX(STRMID(bias[0].v_dtg,8,2)) / 24.
end_time = (end_date - start_date) $
      + (FLOAT(STRMID(bias[nmatch-1].v_dtg,8,2))) / 24.

for n=0, nmatch-1 do begin
  end_date1 = JULDAY(STRMID(bias[n].v_dtg,4,2), $
            STRMID(bias[n].v_dtg,6,2), $
            STRMID(bias[n].v_dtg,0,4))
  end_time1 = (end_date1 - start_date) $
      + (FLOAT(STRMID(bias[n].v_dtg,8,2))) / 24.
  lonDTG[n] =  (end_time1 - start_time) + start_time
  numObs[n] = bias[n].nobs
endfor

std = fields[WHERE((STRTRIM(fields[*].parm) EQ param) and $
             (fields[*].lvl_1 EQ level1) and $
             (STRTRIM(fields[*].geom) EQ geomName) and $
             (fields[*].tau EQ fcstPer) and $
             (STRTRIM(fields[*].obs_type) EQ obType) and $
             (STRTRIM(fields[*].typstat) EQ 'std'), nmatch)]
rms = fields[WHERE((STRTRIM(fields[*].parm) EQ param) and $
             (fields[*].lvl_1 EQ level1) and $
             (STRTRIM(fields[*].geom) EQ geomName) and $
             (fields[*].tau EQ fcstPer) and $
             (STRTRIM(fields[*].obs_type) EQ obType) and $
             (STRTRIM(fields[*].typstat) EQ 'rms'), nmatch)]

for n=0, nmatch-1 do begin
  std1[n] = bias[n].stat_val + std[n].stat_val
  std2[n] = bias[n].stat_val - std[n].stat_val
endfor

dummy = LABEL_DATE(DATE_FORMAT = '%HZ %D%M %Z', offset=start_date)
i = nmatch - 1

;****************************************************
; plot the data
;****************************************************
; title string
;****************************************************
```

```
if STRTRIM(bias[0].typlvl) EQ 'isbr_lvl' then $
  name = modelName + ', ' + geomName + ', ' + param + '!C' $
       + STRTRIM(STRING(bias[0].lvl_1)) $
       + 'mb, ' + STRTRIM(STRING(fcstPer)) + ' hrs, ' + obType $
else $
  name = modelName + ', ' + geomName + ', ' + param + '!C' $
       + STRTRIM(STRING(bias[0].lvl_1)) $
       + 'm, ' + STRTRIM(STRING(fcstPer)) + ' hrs, ' + obType

yname = bias[i].units  ; y-axis title string
minrange = MIN(bias[0:i].stat_val)
if (MIN(std2[0:i]) LT minrange) then $
  minrange = MIN(std2[0:i])
if (MIN(rms[0:i].stat_val) LT minrange) then $
  minrange = MIN(rms[0:i].stat_val)
maxrange = MAX(bias[0:i].stat_val)
if (MAX(std1[0:i]) GT maxrange) then $
  maxrange = MAX(std1[0:i])
if (MAX(rms[0:i].stat_val) GT maxrange) then $
  maxrange = MAX(rms[0:i].stat_val)

;**************************************************
; for debugging
;**************************************************
;print, "std"
;print, std[0:i].stat_val
;print, "rms"
;print, rms[0:i].stat_val
;print, "graph range lies between ", minrange, " and ", maxrange
;print, "lonDtg"
;print, lonDTG[0:i]
;print, "bias"
;print, bias[0:i]
;print, "std1"
;print, std1[0:i]
;print, "std2"
;print, std2[0:i]

!X.MINOR = -1     ;suppress minor tick marks
!Y.MARGIN(1) = 3  ;top margin

;**************************************************
; to create a post script file
;**************************************************
;set_plot, 'PS'
;psfile = filename + '.ps'
;device, /color, filename=psfile

;**************************************************
; to create a gif file
;**************************************************
set_plot, 'Z'
```

```
psfile = filename + '.gif'

PLOT, lonDTG[0:i], bias[0:i].stat_val, $
  YRANGE = [minrange, maxrange], $
  TITLE = name, PSYM = -2, SYMSIZE = 1., $
  XTITLE = 'Forecast Date', $
  YTITLE = yname, $
  XGRIDSTYLE = 1, YGRIDSTYLE = 1, $
  XTICKLEN = 1.0, YTICKLEN = 1.0, $
  XTICKFORMAT = "label_date", $
  XCHARSIZE = 0.7, $
  MAX_VALUE = 30, $
  COLOR = 5, XSTYLE = 2, /DEVICE, /NODATA

for n=1,i do begin
  POLYFILL, [lonDTG(n-1), lonDTG[n-1:n], lonDTG(n)], $
        [bias[n-1].stat_val, std1[n-1:n], bias[n].stat_val], COLOR=2
endfor

for n=1,i do begin
  POLYFILL, [lonDTG(n-1), lonDTG[n-1:n], lonDTG(n)], $
        [bias[n-1].stat_val, std2[n-1:n], bias[n].stat_val], COLOR=2
endfor

; overplot the bias
OPLOT, lonDTG[0:i], bias[0:i].stat_val, PSYM = -2, SYMSIZE = 1., $
  LINE = 0, COLOR = 5, MAX_VALUE = 30

; overplot the std1
OPLOT, lonDTG[0:i], std1[0:i], PSYM = -6, SYMSIZE = 1., $
  LINE = 0, COLOR = 9, MAX_VALUE = 30

; overplot the std2
OPLOT, lonDTG[0:i], std2[0:i], PSYM = -6, SYMSIZE = 1., $
  LINE = 0, COLOR = 9, MAX_VALUE = 30

; overplot the rms
OPLOT, lonDTG[0:i], rms[0:i].stat_val, PSYM = -4, SYMSIZE = 1., $
  LINE = 0, COLOR = 7, MAX_VALUE = 30

; add the legends
XYOUTS, 0.8, 0.16, '!5* - bias', color = 5, /NORMAL ; legend
XYOUTS, 0.8, 0.13, '!MB - std', color = 9, /NORMAL  ;legend
XYOUTS, 0.8, 0.1, '!MV - rms', color = 7, /NORMAL  ;legend

image = TVRD()
WRITE_GIF, psfile, image

;DEVICE, /close_file
SET_PLOT, 'X'

END
```

D. USER INTERFACE

1. Index.html

```
<html>
<!--
Author:   Susie Pace
Date:     25 March 1998
File URL:  model_reports/mverif/index.html
-->

<head><title>FNMOC Model Statistics Display </title></head>
<body bgcolor="#191970" TEXT="#F5F5DC" LINK="#00FF7F"
VLINK="#CCCC66" ALINK="#FF0000">
<FONT SIZE=+1>

<h1><center>Pick a model to see the statistics.</center></h1>
<UL>
  <A HREF="nogaps.html"> NOGAPS</A></P>
  <A HREF="noraps_asia.html">NORAPS_ASIA</A></P>
  <A HREF="noraps_conus.html">NORAPS_CONUS</A></P>
  <A HREF="noraps_europe.html">NORAPS_EUROPE</A></P>
  <A HREF="noraps_ind_ocn.html">NORAPS_IND_OCN</A></P>
  <A HREF="coamps_europe.html">COAMPS_EUROPE</A></P>
  <A HREF="coamps_swasia.html">COAMPS_SOUTHWEST_ASIA</A></P>
  <A HREF="wam.html">WAM_GLOBAL</A></P>
</UL>

<HR>
<CENTER><FONT size="-1"><I> Send Comments Or Suggestions To
Susie Pace: <A HREF="mailto:pacek@fnmoc.navy.mil">
pacek@fnmoc.navy.mil</A>
<BR> Last Update Was On March 25, 1998 </I></FONT></CENTER>

</BODY>
</HTML>
```

2. Nogaps.html

```
<html>
<!--
Author:   Susie Pace
Date:     25 March 1998
File URL:  model_reports/mverif/nogaps.html
-->

<head><title>NOGAPS Verification Display </title></head>
<body bgcolor="#191970" TEXT="#00ff7f" LINK="#00FF7F" VLINK="#CCCC66"
```

```
ALINK="#FF0000">
<form method=GET action="http://devu1/cgi-bin/space3.pl">

<h1><center>Make your selections to see the statistics.</center></h1>

<h3>Model:</h3>
<input type=radio name=model value="nogaps" checked>nogaps

<h3>Geometry:</h3>
<input type=radio name=geometry value="global_360x181" checked>global_360x181
<input type=radio name=geometry value="asia_nest1_appl"> asia_nest1_appl
<input type=radio name=geometry value="conus_nest1_appl"> conus_nest1_appl
<input type=radio name=geometry value="europe_nest1_appl">europe_nest1_appl
<input type=radio name=geometry value="europe_nest2_appl2"> europe_nest2_appl2
<input type=radio name=geometry value="europe_nest3_appl3">europe_nest3_appl3
<input type=radio name=geometry value="ind_ocn_nest1_appl">ind_ocn_nest1_appl
<!--<input type=radio name=geometry value="southwest_asia_nest2_appl">southwest_asia_nest2_appl
<input type=radio name=geometry value="southwest_asia_nest3_appl">southwest_asia_nest3_appl
-->

<h3>Parameters:</h3>
<input type=radio name=parameter value="air_temp"> air_temp
<input type=radio name=parameter value="geop_ht" checked> geop_ht
<input type=radio name=parameter value="pres"> pres
<input type=radio name=parameter value="wnd_spd"> wnd_spd

<h3>Taus:</h3>
<input type=radio name=tau value="0"> 0
<input type=radio name=tau value="12"> 12
<input type=radio name=tau value="24" checked> 24
<input type=radio name=tau value="36"> 36
<input type=radio name=tau value="48"> 48
<input type=radio name=tau value="60"> 60
<input type=radio name=tau value="72"> 72
<input type=radio name=tau value="84"> 84
<input type=radio name=tau value="96"> 96
<input type=radio name=tau value="108"> 108
<input type=radio name=tau value="120"> 120
<input type=radio name=tau value="132"> 132
<input type=radio name=tau value="144"> 144

<h3>Levels: </h3>
<input type=radio name=level value="0">0
<input type=radio name=level value="2">2
<input type=radio name=level value="19.5">19.5
<input type=radio name=level value="1000">1000
<input type=radio name=level value="925">925
<input type=radio name=level value="850">850
<input type=radio name=level value="700">700
<input type=radio name=level value="500" checked>500
<input type=radio name=level value="400">400
<input type=radio name=level value="300">300
```

```
<input type=radio name=level value="250">250
<input type=radio name=level value="200">200
<input type=radio name=level value="150">150
<input type=radio name=level value="100">100

<!--<h3>Statistics:</H3>
bias:     <input type=checkbox name="bias">
stdev:     <input type=checkbox name="stdev">
rms:      <input type=checkbox name="rms">
-->

<h3>Obs types:</h3>
<input type=radio name=obstype value="raob_qc" checked>raob_qc
<input type=radio name=obstype value="sfc_lnd">sfc_lnd
<input type=radio name=obstype value="sfc_ship_met_qc">sfc_ship_met_qc

<h3>Graph Type:</h3>
<!--<input type=radio name=graph value="scatter plot">scatter_plot-->
<input type=radio name=graph value="time series" checked>time_series

<h3>Period: Enter the beginning and ending DTG: e.g., 1998031812</h3>
<input type=text name=beginning maxlength=10 value="1998032512">
<input type=text name=ending maxlength=10 value="1998040500">

<input type=submit>
<input type=reset value="Cancel">

</form>
</body>
</html>
```

3. Noraps_asia.html

```
<html>
<!--
Author:  Susie Pace
Date:    07 November, 1997
File URL:  model_reports/mverif/noraps_asia.html
-->

<head><title>NORAPS_ASIA Verification Display </title></head>
<body bgcolor="#191970" TEXT="#00FF7F" LINK="#00FF7F" VLINK="#CCCC66"
ALINK="#FF0000">
<form method=GET action="http://devu1/cgi-bin/space3.pl">

<h1><center>Make your selections to see the statistics.</center></h1>
<h3>Model:</h3>
<input type=radio name=model value="noraps_asia" checked>noraps_asia
<h3>Geometry:</h3>
<input type=radio name=geometry value="asia_nest1_appl" checked> asia_nest1_appl
```

```
<h3>Parameters:</h3>
<input type=radio name=parameter value="air_temp"> air_temp
<input type=radio name=parameter value="geop_ht" checked> geop_ht
<input type=radio name=parameter value="pres"> pres
<input type=radio name=parameter value="wnd_spd"> wnd_spd

<h3>Taus:</h3>
<input type=radio name=tau value="0"> 0
<input type=radio name=tau value="12"> 12
<input type=radio name=tau value="24" checked> 24
<input type=radio name=tau value="36"> 36
<input type=radio name=tau value="48"> 48

<h3>Levels: </h3>
<input type=radio name=level value="0">0
<input type=radio name=level value="2">2
<input type=radio name=level value="19.5">19.5
<input type=radio name=level value="1000">1000
<input type=radio name=level value="925">925
<input type=radio name=level value="850">850
<input type=radio name=level value="700">700
<input type=radio name=level value="500" checked>500
<input type=radio name=level value="400">400
<input type=radio name=level value="300">300
<input type=radio name=level value="250">250
<input type=radio name=level value="200">200
<input type=radio name=level value="150">150
<input type=radio name=level value="100">100

<!--<h3>Statistics:</H3>
bias:     <input type=checkbox name="bias">
stdev:     <input type=checkbox name="stdev">
rms:      <input type=checkbox name="rms">
-->

<h3>Obs types:</h3>
<input type=radio name=obstype value="raob_qc" checked>raob_qc
<input type=radio name=obstype value="sfc_lnd">sfc_lnd
<input type=radio name=obstype value="sfc_ship_met_qc">sfc_ship_met_qc

<h3>Graph Type:</h3>
<!--<input type=radio name=graph value="scatter plot">scatter_plot-->
<input type=radio name=graph value="time series" checked>time_series

<h3>Period: Enter the beginning and ending DTG: e.g., 1998031812</h3>
<input type=text name=beginning maxlength=10 value="1998031812">
<input type=text name=ending maxlength=10 value="1998033012">

<input type=submit>
<input type=reset value="Cancel">

</form>
```

```
</body>
</html>
```

4. Noraps_conus.html

```
<html>
<!--
Author:   Susie Pace
Date:     25 March 1998
File URL:  model_reports/mverif/noraps_conus.html
-->

<head><title>NORAPS_CONUS Verification Display </title></head>

<body bgcolor="#191970" TEXT="#00FF7F" LINK="#00FF7F" VLINK="#CCCC66"
ALINK="#FF0000">
<form method=GET action="http://devu1/cgi-bin/space3.pl">

<h1><center>Make your selections to see the statistics.</center></h1>
<h3>Model: </h3>
<input type=radio name=model value="noraps_conus" checked> noraps_conus

<h3>Geometry:</h3>
<input type=radio name=geometry value="conus_nest1_appl" checked> conus_nest1_appl

<h3>Parameters:</h3>
<input type=radio name=parameter value="air_temp"> air_temp
<input type=radio name=parameter value="geop_ht" checked> geop_ht
<input type=radio name=parameter value="pres"> pres
<input type=radio name=parameter value="wnd_spd"> wnd_spd

<h3>Taus:</h3>
<input type=radio name=tau value="0"> 0
<input type=radio name=tau value="12"> 12
<input type=radio name=tau value="24" checked> 24
<input type=radio name=tau value="36"> 36
<input type=radio name=tau value="48"> 48

<h3>Levels: </h3>
<input type=radio name=level value="0">0
<input type=radio name=level value="2">2
<input type=radio name=level value="19.5">19.5
<input type=radio name=level value="1000">1000
<input type=radio name=level value="925">925
<input type=radio name=level value="850">850
<input type=radio name=level value="700">700
<input type=radio name=level value="500" checked>500
<input type=radio name=level value="400">400
<input type=radio name=level value="300">300
<input type=radio name=level value="250">250
<input type=radio name=level value="200">200
```

```
<input type=radio name=level value="150">150
<input type=radio name=level value="100">100

<!--<h3>Statistics:</H3>
bias:        <input type=checkbox name="bias">
stdev:        <input type=checkbox name="stdev">
rms:         <input type=checkbox name="rms">
-->

<h3>Obs types:</h3>
<input type=radio name=obstype value="raob_qc" checked>raob_qc
<input type=radio name=obstype value="sfc_lnd">sfc_lnd
<input type=radio name=obstype value="sfc_ship_met_qc">sfc_ship_met_qc

<h3>Graph Type:</h3>
<!--<input type=radio name=graph value="scatter plot">scatter_plot-->
<input type=radio name=graph value="time series" checked>time_series

<h3>Period: Enter the beginning and ending DTG: e.g., 1998031812</h3>
<input type=text name=beginning maxlength=10 value="1998031812">
<input type=text name=ending maxlength=10 value="1998033012">

<input type=submit>
<input type=reset value="Cancel">

</form>
</body>
</html>
```

5. Noraps_europe.html

```
<html>
<!--
Author:   Susie Pace
Date:     25 March 1998
File URL:  model_reports/mverif/noraps_europe.html
-->

<head><title>NORAPS_EUROPE Verification Display </title></head>
<body bgcolor="#191970" TEXT="#00FF7F" LINK="#00FF7F" VLINK="#CCCC66"
ALINK="#FF0000">
<form method=GET action="http://devu1/cgi-bin/space3.pl">

<h1><center>Make your selections to see the statistics.</center></h1>

<h3>Model: </h3>
<input type=radio name=model value="noraps_europe" checked> noraps_europe

<h3>Geometry:</h3>
<input type=radio name=geometry value="europe_nest1_appl" checked>europe_nest1_appl
```

```
<h3>Parameters:</h3>
<input type=radio name=parameter value="air_temp"> air_temp
<input type=radio name=parameter value="geop_ht" checked> geop_ht
<input type=radio name=parameter value="pres"> pres
<input type=radio name=parameter value="wnd_spd"> wnd_spd

<h3>Taus:</h3>
<input type=radio name=tau value="0"> 0
<input type=radio name=tau value="12"> 12
<input type=radio name=tau value="24" checked> 24
<input type=radio name=tau value="36"> 36
<input type=radio name=tau value="48"> 48

<h3>Levels: </h3>
<input type=radio name=level value="0">0
<input type=radio name=level value="2">2
<input type=radio name=level value="19.5">19.5
<input type=radio name=level value="1000">1000
<input type=radio name=level value="925">925
<input type=radio name=level value="850">850
<input type=radio name=level value="700">700
<input type=radio name=level value="500" checked>500
<input type=radio name=level value="400">400
<input type=radio name=level value="300">300
<input type=radio name=level value="250">250
<input type=radio name=level value="200">200
<input type=radio name=level value="150">150
<input type=radio name=level value="100">100

<!--<h3>Statistics:</H3>
bias:      <input type=checkbox name="bias">
stdev:      <input type=checkbox name="stdev">
rms:       <input type=checkbox name="rms">
-->

<h3>Obs types:</h3>
<input type=radio name=obstype value="raob_qc" checked>raob_qc
<input type=radio name=obstype value="sfc_lnd">sfc_lnd
<input type=radio name=obstype value="sfc_ship_met_qc">sfc_ship_met_qc

<h3>Graph Type:</h3>
<!--<input type=radio name=graph value="scatter plot">scatter_plot-->
<input type=radio name=graph value="time series" checked>time_series

<h3>Period: Enter the beginning and ending DTG: e.g., 1998031812</h3>
<input type=text name=beginning maxlength=10 value="1998031812">
<input type=text name=ending maxlength=10 value="1998033012">

<input type=submit>
<input type=reset value="Cancel">

</form>
```

```
</body>
</html>
```

6. Noraps_ind_ocn.html

```
<html>
<!--
Author:   Susie Pace
Date:     25 March 1998
File URL: model_reports/mverif/noraps_ind_ocn.html
-->

<head><title>NORAPS_IND_OCN Verification Display </title></head>
<body bgcolor="#191970" TEXT="#00FF7F" LINK="#00FF7F" VLINK="#CCCC66"
ALINK="#FF0000">
<form method=GET action="http://devu1/cgi-bin/space3.pl">

<h1><center>Make your selections to see the statistics.</center></h1>

<h3>Model: </h3>
<input type=radio name=model value="noraps_ind_ocn" checked>noraps_ind_ocn

<h3>Geometry:</h3>
<input type=radio name=geometry value="ind_ocn_nest1_appl" checked>
ind_ocn_nest1_appl

<h3>Parameters:</h3>
<input type=radio name=parameter value="air_temp"> air_temp
<input type=radio name=parameter value="geop_ht" checked> geop_ht
<input type=radio name=parameter value="pres"> pres
<input type=radio name=parameter value="wnd_spd"> wnd_spd

<h3>Taus:</h3>
<input type=radio name=tau value="0"> 0
<input type=radio name=tau value="12"> 12
<input type=radio name=tau value="24" checked> 24
<input type=radio name=tau value="36"> 36
<input type=radio name=tau value="48"> 48

<h3>Levels: </h3>
<input type=radio name=level value="0">0
<input type=radio name=level value="2">2
<input type=radio name=level value="19.5">19.5
<input type=radio name=level value="1000">1000
<input type=radio name=level value="925">925
<input type=radio name=level value="850">850
<input type=radio name=level value="700">700
<input type=radio name=level value="500" checked>500
<input type=radio name=level value="400">400
<input type=radio name=level value="300">300
<input type=radio name=level value="250">250
```

```
<input type=radio name=level value="200">200
<input type=radio name=level value="150">150
<input type=radio name=level value="100">100

<!--<h3>Statistics:</H3>
bias:       <input type=checkbox name="bias">
stdev:      <input type=checkbox name="stdev">
rms:        <input type=checkbox name="rms">
-->

<h3>Obs types:</h3>
<input type=radio name=obstype value="raob_qc" checked>raob_qc
<input type=radio name=obstype value="sfc_lnd">sfc_lnd
<input type=radio name=obstype value="sfc_ship_met_qc">sfc_ship_met_qc

<h3>Graph Type:</h3>
<!--<input type=radio name=graph value="scatter plot">scatter_plot-->
<input type=radio name=graph value="time series" checked>time_series

<h3>Period: Enter the beginning and ending DTG: e.g., 1998031812</h3>
<input type=text name=beginning maxlength=10 value="1998031812">
<input type=text name=ending maxlength=10 value="1998033012">

<input type=submit>
<input type=reset value="Cancel">

</form>
</body>
</html>
```

7. Coamps_europe.html

```
<html>
<!--
Author:   Susie Pace
Date:     25 March 1998
File URL:  model_reports/mverif/coamps_europe.html
-->

<head><title>COAMPS_EUROPE Verification Display </title></head>
<body bgcolor="#191970" TEXT="#00FF7F" LINK="#00FF7F" VLINK="#CCCC66"
ALINK="#FF0000">
<form method=GET action="http://devu1/cgi-bin/space3.pl">

<h1><center>Make your selections to see the statistics.</center></h1>

<h3>Model: </h3>
<input type=radio name=model value="coamps_europe" checked> coamps_europe

<h3>Geometry:</h3>
<input type=radio name=geometry value="europe_nest2_appl2" checked>
```

```
europe_nest2_appl2
<input type=radio name=geometry value="europe_nest3_appl3">europe_nest3_appl3

<h3>Parameters:</h3>
<input type=radio name=parameter value="air_temp"> air_temp
<input type=radio name=parameter value="geop_ht" checked> geop_ht
<input type=radio name=parameter value="pres"> pres
<input type=radio name=parameter value="wnd_spd"> wnd_spd

<h3>Taus:</h3>
<input type=radio name=tau value="0"> 0
<input type=radio name=tau value="12"> 12
<input type=radio name=tau value="24" checked> 24
<input type=radio name=tau value="36"> 36
<input type=radio name=tau value="48"> 48

<h3>Levels: </h3>
<input type=radio name=level value="0">0
<input type=radio name=level value="2">2
<input type=radio name=level value="19.5">19.5
<input type=radio name=level value="1000">1000
<input type=radio name=level value="925">925
<input type=radio name=level value="850">850
<input type=radio name=level value="700">700
<input type=radio name=level value="500" checked>500
<input type=radio name=level value="400">400
<input type=radio name=level value="300">300
<input type=radio name=level value="250">250
<input type=radio name=level value="200">200
<input type=radio name=level value="150">150
<input type=radio name=level value="100">100

<!--<h3>Statistics:</H3>
bias:       <input type=checkbox name="bias">
stdev:       <input type=checkbox name="stdev">
rms:        <input type=checkbox name="rms">
-->

<h3>Obs types:</h3>
<input type=radio name=obstype value="raob_qc" checked>raob_qc
<input type=radio name=obstype value="sfc_lnd">sfc_lnd
<input type=radio name=obstype value="sfc_ship_met_qc">sfc_ship_met_qc

<h3>Graph Type:</h3>
<!--<input type=radio name=graph value="scatter plot">scatter_plot-->
<input type=radio name=graph value="time series" checked>time_series

<h3>Period: Enter the beginning and ending DTG: e.g., 1998031812</h3>
<input type=text name=beginning maxlength=10 value="1998031812">
<input type=text name=ending maxlength=10 value="1998033012">

<input type=submit>
```

```
<input type=reset value="Cancel">

</form>
</body>
</html>
```

8. Coamps_southwest_asia.html

```
<html>
<!--
Author:   Susie Pace
Date:     25 March 1998
File URL:  model_reports/mverif/coamps_swasia.html
-->

<head><title>COAMPS_SOUTHWEST_ASIA Verification Display </title></head>
<body bgcolor="#191970" TEXT="#00FF7F" LINK="#00FF7F" VLINK="#CCCC66"
ALINK="#FF0000">
<form method=GET action="http://devu1/cgi-bin/space3.pl">

<h1><center>Make your selections to see the statistics.</center></h1>

<h3>Model: </h3>
<input type=radio name=model value="coamps_sw_asia" checked>
coamps_southwest_asia

<h3>Geometry:</h3>
<input type=radio name=geometry value="southwest_asia_nest2_appl" checked>
southwest_asia_nest2_appl
<input type=radio name=geometry value="southwest_asia_nest3_appl">
southwest_asia_nest3_appl

<h3>Parameters:</h3>
<input type=radio name=parameter value="air_temp"> air_temp
<input type=radio name=parameter value="geop_ht" checked> geop_ht
<input type=radio name=parameter value="pres"> pres
<input type=radio name=parameter value="wnd_spd"> wnd_spd

<h3>Taus:</h3>
<input type=radio name=tau value="0"> 0
<input type=radio name=tau value="12"> 12
<input type=radio name=tau value="24" checked> 24
<input type=radio name=tau value="36"> 36
<input type=radio name=tau value="48"> 48

<h3>Levels: </h3>
<input type=radio name=level value="0">0
<input type=radio name=level value="2">2
<input type=radio name=level value="19.5">19.5
<input type=radio name=level value="1000">1000
<input type=radio name=level value="925">925
```

```
<input type=radio name=level value="850">850
<input type=radio name=level value="700">700
<input type=radio name=level value="500" checked>500
<input type=radio name=level value="400">400
<input type=radio name=level value="300">300
<input type=radio name=level value="250">250
<input type=radio name=level value="200">200
<input type=radio name=level value="150">150
<input type=radio name=level value="100">100

<!--<h3>Statistics:</H3>
bias:       <input type=checkbox name="bias">
stdev:      <input type=checkbox name="stdev">
rms:        <input type=checkbox name="rms">
-->

<h3>Obs types:</h3>
<input type=radio name=obstype value="raob_qc" checked>raob_qc
<input type=radio name=obstype value="sfc_lnd">sfc_lnd
<input type=radio name=obstype value="sfc_ship_met_qc">sfc_ship_met_qc

<h3>Graph Type:</h3>
<!--<input type=radio name=graph value="scatter plot">scatter_plot-->
<input type=radio name=graph value="time series" checked>time_series

<h3>Period: Enter the beginning and ending DTG: e.g., 1998031812</h3>
<input type=text name=beginning maxlength=10 value="1998031812">
<input type=text name=ending maxlength=10 value="1998033012">

<input type=submit>
<input type=reset value="Cancel">

</form>
</body>
</html>
```

9. Wam_Global.html

```
<html>
<!--
Author:   Susie Pace
Date:     25 March 1998
File URL: model_reports/mverif/wam.html
-->

<head><title>WAM_GLOBAL Verification Display </title></head>
<body bgcolor="#191970" TEXT="#00FF7F" LINK="#00FF7F" VLINK="#CCCC66"
ALINK="#FF0000">
<form method=GET action="http://devu1/cgi-bin/space3.pl">

<h1><center>Make your selections to see the statistics.</center></h1>
```

```
<h3>Model: </h3>
<input type=radio name=model value="wam_global" checked> wam_global

<h3>Geometry:</h3>
<input type=radio name=geometry value="global_360x181" checked>
global_360x181

<h3>Parameters:</h3>
<input type=radio name=parameter value="sig_wav_ht" checked> sig_wav_ht
<input type=radio name=parameter value="peak_wav_per"> peak_wav_per

<h3>Taus:</h3>
<input type=radio name=tau value="0"> 0
<input type=radio name=tau value="12"> 12
<input type=radio name=tau value="24" checked> 24
<input type=radio name=tau value="36"> 36
<input type=radio name=tau value="48"> 48
<input type=radio name=tau value="60"> 60
<input type=radio name=tau value="72"> 72
<input type=radio name=tau value="84"> 84
<input type=radio name=tau value="96"> 96
<input type=radio name=tau value="108"> 108
<input type=radio name=tau value="120"> 120

<h3>Levels: </h3>
<input type=radio name=level value="0" checked>0

<!--<h3>Statistics:</H3>
bias:       <input type=checkbox name="bias">
stdev:      <input type=checkbox name="stdev">
rms:        <input type=checkbox name="rms">
-->

<h3>Obs types:</h3>
<input type=radio name=obstype value="sfc_ship" checked>sfc_ship
<!--<input type=radio name=obstype value="alty">alty-->

<h3>Graph Type:</h3>
<!--<input type=radio name=graph value="scatter plot">scatter_plot-->
<input type=radio name=graph value="time series" checked>time_series

<h3>Period: Enter the beginning and ending DTG: e.g., 1998031812</h3>
<input type=text name=beginning maxlength=10 value="1998031812">
<input type=text name=ending maxlength=10 value="1998033012">

<input type=submit>
<input type=reset value="Cancel">

</form>
</body>
</html>
```

10. Procform.pl

```
#!/usr/local/bin/perl
# space3.pl - Try to batch in runjob to retreive the data
# and run the IDL programs to create the graphs

#Use the form library
require "space2.pl";

########## STEP 1: Get and decode the input from the form ##########

#get the data from the form
&ReadParse(*input);

########## STEP 2: Process the information from the form ##########

$procid = $$;
`export procid`;

#split $query_string into name=value pairs
local(*FormData) = @_ if @_; #make an alias for the arg
$query_string=$ENV{'QUERY_STRING'};

foreach $name_value (split('&', $query_string)) {

  #translate any plus signs in the pair string into spaces:
  $name_value =~ tr/+/ /;

  #split the name=value pair into a separate name and value:
  ($name, $value) = split ('=', $name_value);

  #translate escaped hex numbers back to 8-bit char:
  $name =~ s/%(..)/pack("C", hex($1))/eg;
  $value =~ s/%(..)/pack("C", hex($1))/eg;

  #convert the names and values into named, assigned var;
  if (defined($FormData{$name})) {
    $FormData{$name} .= "\0$value";
  } else {
    $FormData{$name} = $value;
  }

  if ($name eq 'model') {
  $model = $value;
  `export model`;
  #exit 0 if ($model eq '')

  } elsif ($name eq 'geometry') {
  $geometry = $value;
  `export geometry`;
  #exit 0 if ($geometry eq '')
  } elsif ($name eq 'parameter') {
  $parameter = $value;
  `export parameter`;
  #exit 0 if ($parameter eq '')

  } elsif ($name eq 'tau') {
  $tau = $value;
  `export tau`;
  #exit 0 if ($tau eq '')

  } elsif ($name eq 'level') {
  $level = $value;
  `export level`;
  #exit 0 if ($level eq '')

  } elsif ($name eq 'stats') {
  $stats = $value;
  #`export stats`;

  } elsif ($name eq 'obstype') {
  $obstype = $value;
  `export obstype`;
  #exit 0 if ($obstype eq '')

  } elsif ($name eq 'graph') {
  $graph = $value;
  `export graph`;
  #exit 0 if ($graph eq '')

  } elsif ($name eq 'beginning') {
  $beginning = $value;
  `export beginning`;
  #exit 0 if ($beginning eq '')

  } elsif ($name eq 'ending') {
  $ending = $value;
  `export ending`;
  #exit 0 if ($ending eq '')

  } else {
   print "no matching env var";
  }

}

#process the request by runjob
`/a/ops/bin/runjob -h div60-3 -u pacek -t sun -d /home/pubs43/tmp -j get_data.ksh -e "pid=$procid
MODEL=$model BDTG=$beginning EDTG=$ending PARM_NAME=$parameter LVL_1=$level
FCSTPER=$tau OBSTYPE=$obstype GEOM_NAME=$geometry" > $procid.out 2>&1`;


########## STEP 3: Reply by outputting a new document ##########
```

```
#$Image = "http://152.80.13.201/~pacek/gif/$procid.gif";
$Image = "/home/pubs43/tmp/$procid.gif";

#!!!!! This portion worked for WAM !!!!!#
#
# Output the MIME-type header, followed by two newlines:
print "Content-type: image/gif\n\n";
#
# loop until the gif file is transferred to the web server
# when the gif file arrives, display on the web browser
#
while (! (-e $Image)) {
  sleep 5;
}

open (IMAGE, $Image);
print <IMAGE>;
close (IMAGE);

`rm $Image`;

#print "<HTML><HEAD><TITLE> Model Verification Reply </TITLE></HEAD>\n";
#print "</BODY></HTML>\n";
#
#!!!!! Down to here !!!!!#

#Trying to handle the timed out error

#if (-e $Image) {
#  print "Content-type: image/gif\n\n";
#  open (IMAGE, $Image);
#  print <IMAGE>;
#  close (IMAGE);
#this causes the runjob to be batched in multiple time and PID change,
#end up in an infinite loop
#} else {
#  print "refresh: 10; \n";
#  print "Content-type: text/html\n\n";
#  print "<HTML><HEAD><TITLE>Model Statistics Display</TITLE></HEAD>\n";
#  print "<BODY BGCOLOR=NAVY TEXT=WHITE>";
#  print "<H1><CENTER>Please be patient, the image is being created</CENTER></H1>\n";
#  print "Processing is done when a graph is displayed\n";
#}

########## END OF space3.pl ##########
```

11. Get_data.ksh

```
#!/bin/sh
/bin/ksh <<'EOT'
. /a/ops/isis/db_init/isis_init_ofs.ksh
```

```
#set -x
cd /d/tmp
export DB_DIR=/d/model-stats/
cd $DB_DIR

export FILENAME=$pid
export TMPFN=$pid"tmp"
SLASH=_

if [[ $MODEL = nogaps ]]
then
  MODEL="$MODEL$SLASH$GEOM_NAME"
fi

print $MODEL $GEOM_NAME $FCSTPER $PARM_NAME $OBSTYPE $LVL_1 $BDTG $EDTG

empcmd $DB_DIR/stat_db 'select bypass_lock verif_date,sample_size,parm_name,
unit_name,geom_name,lvl_type,level_1 convert to decimal(8,2),
tau,stat_type,stat_value convert to decimal(8,2),verif_source,
obs_type from $MODEL where verif_date range $BDTG to $EDTG and
parm_name="$PARM_NAME" and geom_name="$GEOM_NAME" and tau="$FCSTPER"
and obs_type="$OBSTYPE" and level_1="$LVL_1" into "$TMPFN";'

awk '/^[0-9]/ \
{printf ("%-12s%-5d%-20s%-15s%-30s%-15s%-8.2f%-5d%-15s%-8.2f%-10s%-25s\n", \
 $1,$2,$3,$4,$5,$6,$7,$8,$9,$10,$11,$12)}' $TMPFN > $FILENAME

#print "sourcing the IDL setup script"
. /h/idl/idl_5/bin/idl_setup.ksh

#print $PARM_NAME $LVL_1 $FCSTPER $OBSTYPE $GEOM_NAME
idl -rt=plot_data

if [[ -f $FILENAME.gif ]]
then
  ftpbatch -h devu1 -s "cd /home/pubs43/tmp/; put $FILENAME.gif"
fi

rm $pid*

exit 0
EOT
exit 0
```

APPENDIX C

A. STATTEST.F90

```
    program stattest
C
C.............................START PROLOGUE............................
C
C  SCCS IDENTIFICATION:  @(#)stattest.f90          1.1 04/24/98
C
C  CONFIGURATION IDENTIFICATION:   NONE
C
C  MODULE NAME: stattest
C
C  DESCRIPTION: Program to test the stat lib
C
C  COPYRIGHT:              (c) 1998 FLENUMMETOCCEN
C                          U.S. GOVERNMENT DOMAIN
C                          ALL RIGHTS RESERVED
C
C  CONTRACT NUMBER AND TITLE:   N/A
C
C  REFERENCES: NONE
C
C  CLASSIFICATION:  Unclassified
C
C  RESTRICTIONS:   NONE
C
C  COMPUTER/OPERATING SYSTEM
C           DEPENDENCIES:  Cray UNICOS
C
C  LIBRARIES OF RESIDENCE: /a/ops/bin
C
C  USAGE:
C    stattest
C
C  PARAMETERS:
C     Name        Type      Usage       Description
C   ----------   ----------   -------  ----------------------------
C
C  PARAMETERS:
C     Name        Type      Usage       Description
C   ----------   ----------   -------  ----------------------------
C
C  COMMON BLOCKS: N/A
C
C  FILES: N/A
C
C  DATA BASES: N/A
```

```
C
C  COMPILER DEPENDENCIES: f90
C
C  COMPILE OPTIONS:  -f fixed -c
C
C  MAKEFILE: Located at /a/ops/app/mverif/test/maketest
C          UNICOS make
C
C  RECORD OF CHANGES:
C
C  <<CHANGE NOTICE>> Version 1.1 (29 Apr 1998) -- Kyongsuk Pace
C     Initial submission
C
C..............................END PROLOGUE.............................
C
      implicit none

      integer :: size
      parameter(size=10)

      real   :: stat
      real   :: arr1(size)
      real   :: arr2(size)

      character(4) :: geom

      geom(1:4) = 'NONE'

      arr2 = (/288.6, 304.8, 301.4, 293.2, 293.2,
     2        297.6, 295.8, 291.0, 285.2, 287.8/)
      arr1 = (/289.29, 302.26, 302.14, 294.92, 294.92,
     2        296.25, 295.37, 292.32, 285.15, 288.69/)

      CALL COMPUTE_BIAS(arr1,arr2,size,geom,stat)
      write (0, '("bias = ", f8.2)') stat

      CALL COMPUTE_STD(arr1,arr2,size,geom,stat)
      write (0, '("std = ", f8.2)') stat

      CALL COMPUTE_RMS(arr1,arr2,size,geom,stat)
      write (0, '("rms = ", f8.2)') stat

      stop 'Normal End'

      end
```

B. STATISTICS BY STATISTICS LIBRARY SUBROUTINES

```
Script started on Wed Feb 11 17:21:26 1998
[/dev/ttyp017]
s{j91}/home/pacek/mverif/test>tstattest
```

```
bias =    0.27
std =    1.31
rms =    1.34
 STOP Normal End
 STOP executed at line 28 in Fortran routine 'STATTEST'
 CPU: 0.010s,  Wallclock: 0.011s,  10.6% of 8-CPU Machine
 Memory HWM: 1595052, Stack HWM: 803866, Stack segment expansions: 0
{j91}/home/pacek/mverif/test
Script finished on Wed Feb 11 17:21:34 1998
```

C. STATISTICS BY MICROSOFT EXCEL

array 1	array 2	diff	diff sqr		
288.6	289.29		-0.69	0.4761	
304.8	302.26		2.54	6.4516	
301.4	302.14		-0.74	0.5476	
293.2	294.92		-1.72	2.9584	
293.2	294.92		-1.72	2.9584	
297.6	296.25		1.35	1.8225	
295.8	295.37		0.43	0.1849	
291	292.32		-1.32	1.7424	
285.2	285.15		0.05	0.0025	
287.8	288.69		-0.89	0.7921	
sum		-2.71	17.9365		
bias		-0.271		sum/count	
count		10			
stdev			1.3115		sqrt(sum of diff sqr/count - bias*bias)
rms			1.3392		sqrt(sum of diff sqr/count)

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